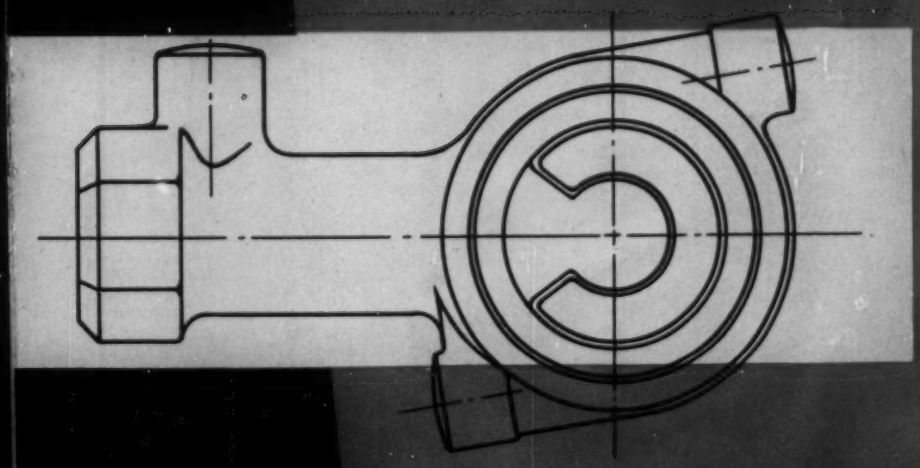
FEBRUARY 7, 1957
EVERY OTHER THURSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Copper Alloy Forgings

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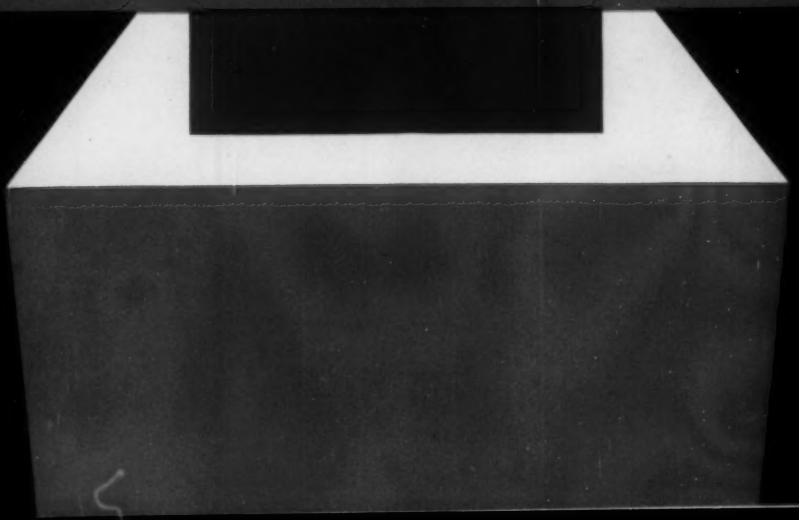


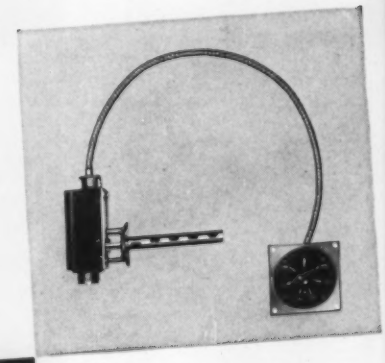
FARNSWORTH

S.S.White

Flexible Shafts Withstand Temperature Extremes!

A leading aircraft manufacturer has used S.S. WHITE flexible shafts for many years to transmit control between this graduated dial and aircraft thermostat. He finds that under any kind of temperature conditions, there is no measurable variation in torque to turn the shaft, or in torsional deflection required to initiate cam movement over the temperature range!

This ability to withstand temperature extremes is only one of the many remote control and power drive advantages industry has discovered in S.S. WHITE flexible shafts. Perhaps they can help you to simplify control or product design . . . cut your production costs . . . speed assembly. These quality shafts range from small to large sizes, and up to 12 feet in length. The assistance of our engineering staff in helping you work out a flexible shaft application for your product is yours for the asking. Just write to



S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts. Write for Bulletin 5601.

S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Circle 401 on page 19

NEW Ross — Starline

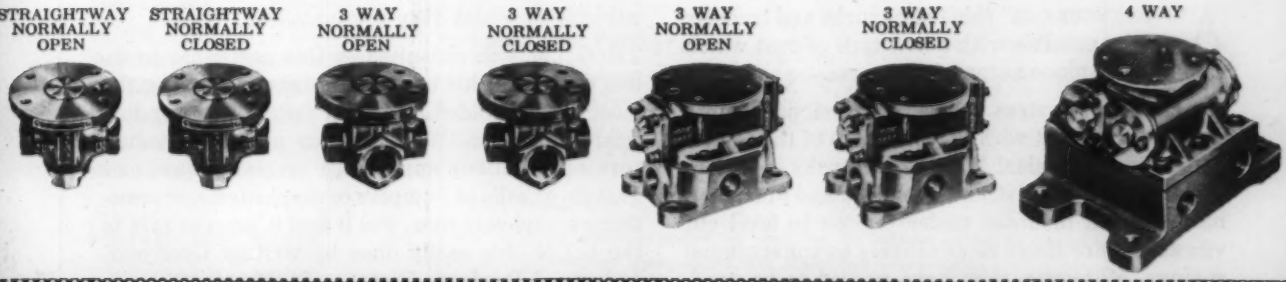
air control valve series

NEW long life

WHITE STAR SPOOL SOLENOID | GOLD STAR OIL-IMMERSED SOLENOID | BLUE STAR MV | BLUE STAR TD | BLUE STAR WV

NEW match any head to any valve body!

STRAIGHTWAY NORMALLY OPEN | STRAIGHTWAY NORMALLY CLOSED | 3 WAY NORMALLY OPEN | 3 WAY NORMALLY CLOSED | 3 WAY NORMALLY OPEN | 3 WAY NORMALLY CLOSED | 4 WAY



Tests indicate a trouble-free life of over 25 million cycles for valves with the spool solenoid pilot section, and *more than 40 million for all other Starline* valves shown.

Heads and bodies are completely and instantly interchangeable. Sizes from ¼″ to 1¼″. Even *more* Starline models coming later. Write for Starline data file.

A Galaxy of New Air-Control Stars Are Coming Your Way From

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Circle 404 on Page 19

GOODYEAR INDUSTRIAL PRODUCTS
GT -Specified
Torsional rubber spring for Truck and Tractor Seats
1. Special, tough rubber compound to withstand constant torque
2. Strong rubber-to-metal bonds
3. Top Plate Assembly
4. Base Plate Assembly
5. Flanged Bearing

Photo courtesy Bostrom Mfg. Co., Milwaukee, Wis.

G.T.M. helps give "passenger car" ride to trucks and tractors

A "PASSENGER CAR" ride from trucks and tractors is now possible with a new type of seat which embodies a unique suspension system.

Heart of this system is a set of torsional rubber springs developed with the close help of the G.T.M. –Goodyear Technical Man. These husky cylinders of rubber are especially compounded and precision-molded, then mounted under torsion to level out vibrations *five times as effectively* as conventional springs. Moreover, they have proved to be unaffected by climatic changes and *as durable as the vehicles on which they are installed.*

The G.T.M. was consulted on this particular problem because of his broad experience in getting the most out of molded rubber in virtually any industrial application. Whether your problem involves torsional rubber springs or engine mounts or gaskets or rolls or bumpers or diaphragms or something completely new, you'll find it pays to talk to the G.T.M. It's easily done by writing Goodyear, Industrial Products Division, St. Marys, Ohio, or Akron 16, Ohio.

MOLDED GOODS by

GOODYEAR

THE GREATEST NAME IN RUBBER

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

Circle 405 on page 19

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

February 7, 1957
Volume 29—No. 3

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Machine Design is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations performing design engineering of products are also eligible.

Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

When requesting changes of address, etc., please allow four to six weeks for processing

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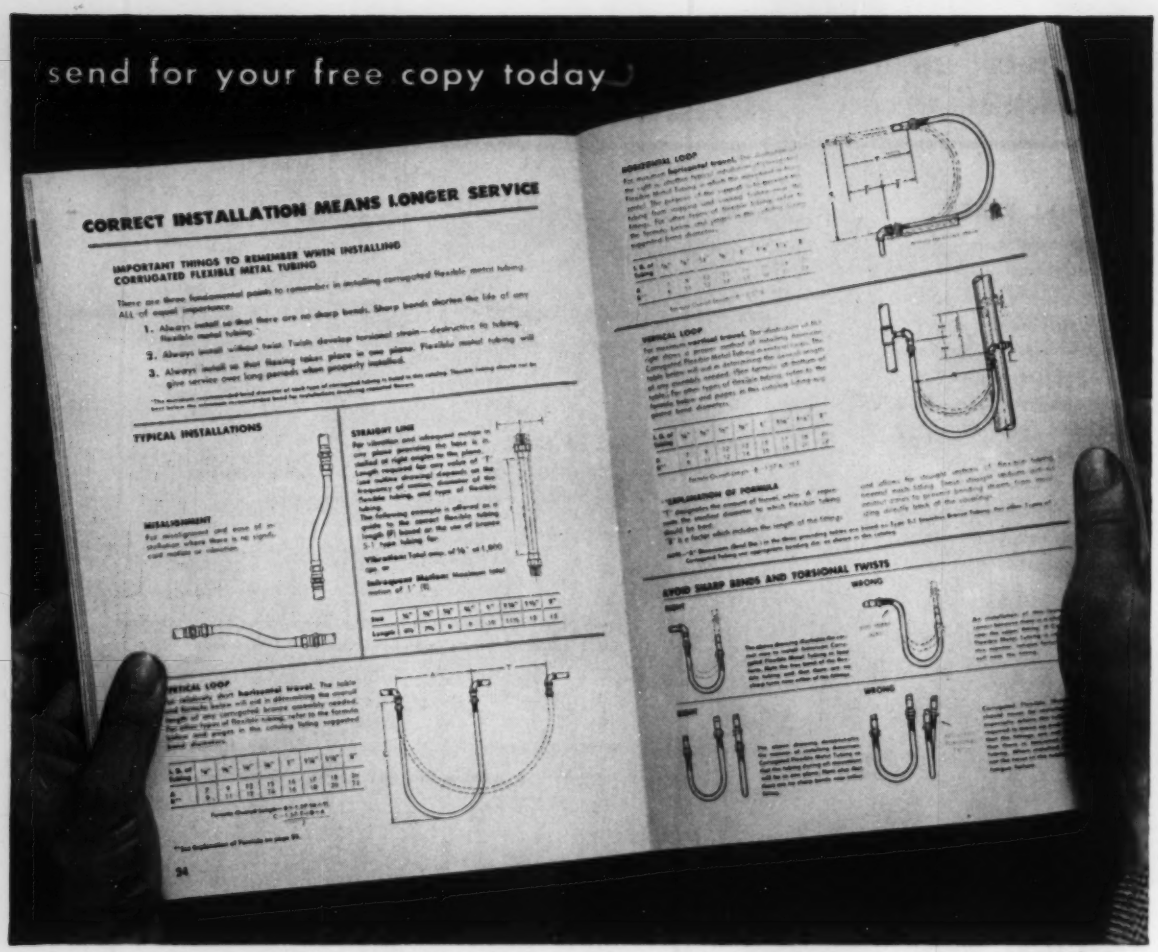

New catalog simplifies selection and ordering of flexible metal hose and tubing

Here's the most complete, most up-to-date catalog on flexible metal hose available today.

Full description of the two basic types of flexible metal hose: corrugated metal tubing and strip-wound hose. Suggestions on correct installation of flexible metal connectors — specifications, bend diameters, length of tubing needed. Type designations and descriptions of flexible hose and tubing made of brass, bronze, aluminum, stainless steel, steel, Monel. Descriptions of end fittings.

Guide to special flexible metal hoses for special jobs: Vibration Eliminators; Flexpipe* flexible connectors; Presstite† connectors for laundry and garment pressing machines; Bracketubes for steam-heated platen presses; Sealtite* flexible, liquid-tight electrical conduit; tank car unloading hose assemblies; tar and asphalt hose assemblies; insulated hose; exhaust and air intake hoses; flexible lamp arms; shielding conduit; Flexlube* oil feed and coolant lines; and other products for special services.

*Trademark †Reg. U.S. Pat. Off. 56185

WHEREVER CONNECTORS MUST MOVE **AMERICAN**

flexible metal hose and tubing

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MAIL COUPON TODAY FOR YOUR FREE FLEXIBLE METAL HOSE AND TUBING CATALOG!

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Engineering News Roundup

Engineers' Week to Feature Profession's Aims and Status

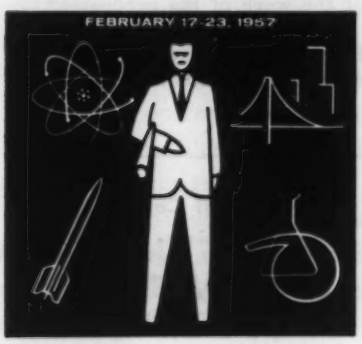
WASHINGTON, D. C. — National Engineers' Week, February 17 to 23, will give industries and professional groups the occasion to bring to the general public the story of their engineering programs, an account of their engineering accomplishments, and the status of the profession in general. Started in 1951, Engineers' Week has grown to a nation-wide observance recognized by the President of the U. S., state governors, and the mayors of most major cities.

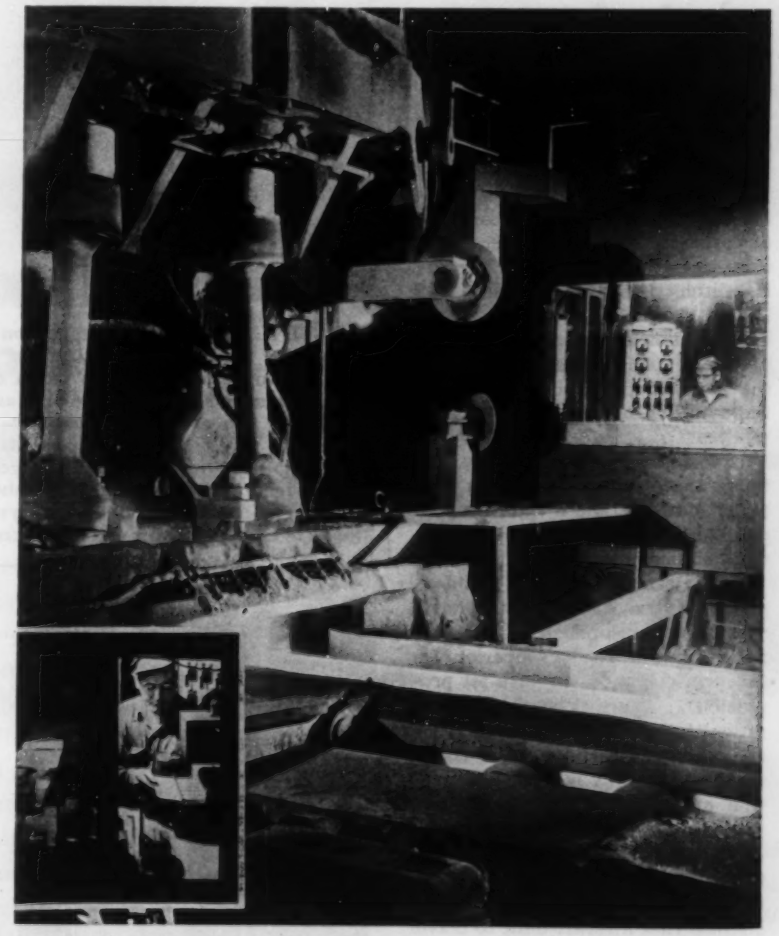
The week of Washington's Birthday was selected for these observations because the nation's first president was himself a notable engineer.

Theme for the 1957 period is "Engineering . . . America's Great Resource." Emphasis is to be placed on the conservation and replenishment of this resource. In particular, prospective engineers now in their teens are to be impressed with the opportunities for personal achievement and public service.

Companies and societies are encouraged to use plant tours, meetings and other publicity mediums to promote the week's objectives

On a national scale, the accomplishments of engineers in certain fields will be dramatized. Such general subjects include the various aspects of atomic energy and


NATIONAL ENGINEERS' WEEK
FEBRUARY 17-23, 1957
ENGINEERING...America's Great Resource
Sponsored by NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS



CARD-CONTROLLED STEEL MILL, possibly the world's first, is this installation at the Brackenridge Works of Allegheny Ludlum Steel Corp. Punched cards determine the number of passes, the speed of rolling, and the sequence and amount of slab reduction. More uniform quality of finished product is the objective. As many as 15 programmed passes with accuracies of about 0.01-in. can be arranged at one time. A selection from six mill speeds can be recorded on each card. Maximum opening of the mill is 9.99 in.; top screwdown speed is 40 in. per minute. Operator keeps a large file of card schedules for correspondingly wide variety of mill products.

the federal highway program.

Requests for promotional aids and additional information can be directed to the sponsor of Engineers' Week: National Society of Professional Engineers, 2029 K Street N. W., Washington 6, D. C.

Airplane Propellers Seen Not Outmoded

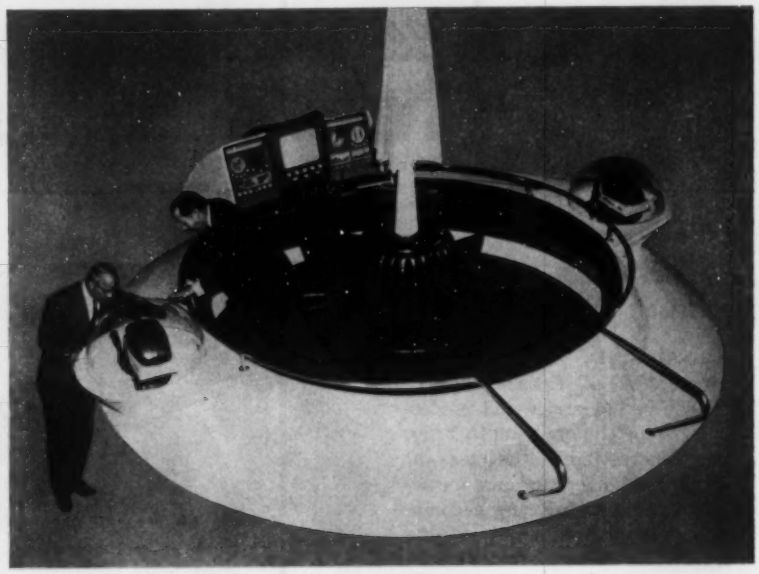
WINDSOR LOCKS, CONN.—The airplane propeller, far from being rendered old fashioned in this age of jet propulsion, continues to demonstrate increasing use and efficiency. This was the recent observation of Anthony F. Dernbach, chief development engineer for the Hamilton Standard division of United Aircraft Corp. Mr. Dernbach acknowledged that the place of the propeller "has been one of the most controversial subjects in the aviation industry over the past ten years.

"The fact remains, however, that today there exists a vigorous propeller industry, and a vigorous propeller-driven development program, with no end in sight."

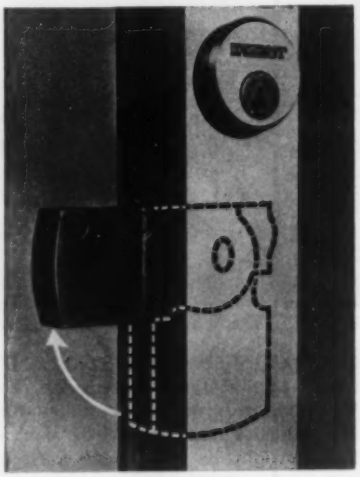
Mr. Dernbach told a student group of the ASME that today's continued development of the propeller is due to its superior efficiency, compared to pure jet propulsion. "There is a place in the propulsion spectrum for both types of engines," he said, "and a major question of today is the determination of those regions where each type is respectively best suited."

Although the short-range fighter type of aircraft may never again use propellers, Mr. Dernbach claimed that aircraft built to travel far as well as fast will benefit by the superior efficiency of the turboprop engine. This, he said, is due to improvement in thrust output and specific fuel consumption of the engine-propeller combination.

Mr. Dernbach described the complex modern propeller as "one of the most efficient pieces of machinery devised by man. . . Development of a propeller," he asserted, "involves the highest talents of all branches of the engineering sciences."



FLOATING SAUCER is a suggestion of Evinrude Motors to stimulate new designs for fishing boats. Called the Fisherman, the circular craft is powered by two outboard motors set in domed wells across its 14-ft diameter. The Fisherman seats eight around an 11½-ft center mast—six in fishing chairs and two at the boat controls. Central feature of the controls is a 130-sq in. TV screen which presents the view from an underwater color camera. Other controls include target-searching sonar gear, depth-finding and navigating equipment. The Fisherman has no rudder and no wheel. Steering is done by a hydraulic system which can rotate the outboards nearly 360 degrees. Draft of the Fisherman is 6 in.



MAXIMUM SECURITY is both name and function of this new lock recently announced by Kawneer Co. The lock is intended for certain narrow-stile aluminum-and-glass doors which allow insufficient space for conventional types. Construction of the Maximum Security lock permits a bolt throw of 1⅜-in. from a backset as short as 1-in.

Aid For Aides Is Planned To Beat Engineer Shortage

LA CROSSE, WIS. — One company faced with the common shortage of graduate engineers is currently attacking its problem by underwriting the training of engineering aides. The plan is expected to maintain a supply of two-year technicians who can assume some of the work of the graduates.

In co-operation with La Crosse State College, the Trane Co. is sponsoring eight two-year pre-engi-

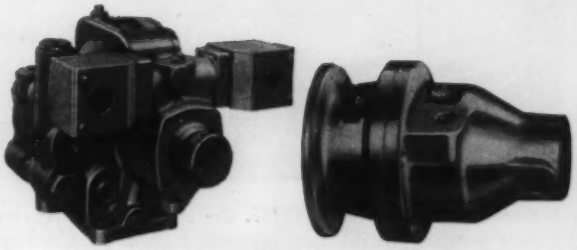
Front Cover

Forging dies squeezing a billet of hot metal on this issue's front cover symbolize the process of forging copper alloys. Artist George Farnsworth has combined this theme with a drawing of an actual forged copper alloy part to keynote Arthur Heim's article on Page 100.

ANOTHER TRIUMPH IN MACHINE DESIGN THAT USES OILGEAR "ANY-SPEED" DRIVE FEEDS

Barber-Colman's new high-speed hobbing machine may be totally different from the machines you build. But the machine design problems they encountered in developing this machine could very well be your problems. Among the problems encountered was that of feed. To solve this problem, Barber-Colman selected Oilgear Fluid Power Feeds. These feeds give them the infinitely variable output to provide a hobbing feed range of .020" to 1" per minute. In addition, they provide a far more constant hobbing feed despite changes in load or system temperatures. They also provide cushioned, positive, precise, fast-acting electro-hydraulic control of feed, rapid traverse, and stop through automatic switches. Finally, they provide power for operating ten auxiliary cylinders and three valves. One Oilgear type AX-311 Pump supplies fluid power for the entire machine.

You have much to gain if you stop a moment and ask: "Why are leading machine and machine tool builders turning to Oilgear? Am *I* missing an opportunity to improve machine performance?" Why don't you compare your machine needs with what Oilgear "ANY-SPEED" Drives and Feeds can provide? You can rest assured that we will recommend our product only when it is to your advantage. Tell us your needs. We'll give you a specific appraisal of the possibilities. Write now. THE OILGEAR COMPANY, 1568 W. Pierce Street, Milwaukee 4, Wisconsin.



Type AX-311 PUMP and Type H-311 MOTOR
OILGEAR "ANY-SPEED" DRIVE FEED

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS & VALVES

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

neering scholarships of $500 each. Purpose of the program is to interest young men to train as engineering technicians by completing a strong two-year curriculum which stresses mathematics and science. The curriculum includes established courses at La Crosse State College and two classes of the University of Wisconsin Extension Div.

After the two-year period, the scholarship recipients will join Trane and relieve graduate engineers of some of their more time-consuming responsibilities. As added incentive, Trane plans to arrange summer employment in its engineering department while the students are participating in the program. After completing the course, the students will be able to join Trane as engineering technicians. Should they decide to go on with their schooling, the students will be free to do so and will receive credits toward engineering degrees for courses completed during the special program.

Eligibility is limited to the top quarter of senior boys in the high schools participating. Candidates should have completed two years of high school mathematics and one of science. In all cases, the scholarship winners must be in need of financial aid.

Applicants will be selected by a three member committee, including one Trane Co. representative and two from La Crosse State College. Final selection will be based on aptitude test scores, scholastic record and interview results.

MIDAS-TOUCHED DE SOTO, the 1957 Golden Adventurer, has a 345-hp engine with 345 cu in. displacement. Refinements of the De Soto engine in this sports type car also include a high-performance camshaft, heavier valve springs, dual four-barrel carburetors, dual-breaker distributor and hemispherical combustion chambers. Bore size is 3.80 in. The Adventurer, offered only in exterior and interior color combinations of gold with black or white, is available in hardtop or convertible body styles.

Commercial Shapes Now Rolled From Copper and Alloy Powder

NEW YORK, N. Y.—A new process for making copper strip, tubing and similar end products directly from copper powder is being put into operation in the U. S. by the Chemetals Corp. with help from the E. W. Bliss Co. The new process involves substantially less capital equipment and operating cost than conventional copper fabricating methods.

The powder process avoids the preparation of copper ingots and the annealing steps in present methods. It also uses 80 per cent less heat and power than current practice, and requires less manual labor. It eliminates much of the air pollution characteristic of copper-working operations. Plants of comparatively small size and capital which adopt the process will be able to market copper products on a basis competitive with larger manufacturers.

Chemetals Corp. holds U. S. rights to the process from Mannesman AKT and Sundwiger Messing-

Topics

Atomobile, a likely name for a nuclear-powered car, probably will never be used. The Nuclear Advisory Committee of the Society of Automotive Engineers recently reported that shielding for the reactor would present a weight problem—that an atomic auto's power plant would weigh some 40 tons. Faint hope for the atomobile lies in now-secret military work on nuclear propulsion or development of an efficient means of storing energy.

• • •

An increasing number of companies are opening offices in Florida to lure engineers into their employ. The theory seems to be that it's easier to hire men to work in a place where they want to live. On the other hand, proving that the grass is always greener on the other side of the Mason-Dixon line, only 25 per cent of 1956 University of Florida graduates took jobs in their home state.

• • •

Council for Atomic Age Studies, believed to be the first such effort by an American university, has been created by Columbia University. Objective of the council is to make the university a center for the study of problems facing society as a result of the development of atomic energy.

• • •

Hi-Fi equipment eliminates guesswork by grinder operators, who depend upon the sound made by the dressing tool during its pass across the wheel to tell them when the latter has "sparked out," thus indicating a properly dressed wheel. Sound made by the tool is amplified above other sounds in the area. Spokesmen at Johnson Motors, where this equipment is installed, foresee sound amplification applied to such uses as hearing a part seating against a shoulder in an assembly operation or as an indication of changing load or volume.

• • •

Giving doors the air is seen as a method of luring customers into a store. A new development provides a regulated curtain of air in the doorway to keep out cold and to facilitate entrance. Glass doors unfold from the walls to replace the air at closing time.

Circle 407 on page 19→

BRONZE

. . . . Through the Ages

Since the dawn of recorded history man has consistently called on bronze for the most arduous of metal-working tasks . . . Today leaders of every industry are asking Bound Brook, the world's leading specialists in sintered bearings, to solve their bearing problems. COMPO oil retaining bronze bearings can be purchased from stock for most applications or specially alloyed and tailored to meet your requirements. Call your Bound Brook man now.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

ESTABLISHED 1883

werk in Dusseldorf and Sundwig, Germany, respectively. E. W. Bliss Co. has recently acquired a 20 per cent interest in the Chemetals company.

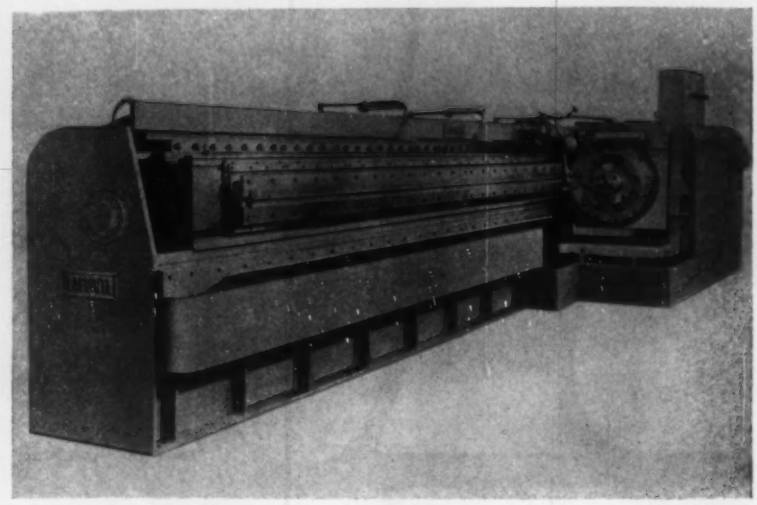
Ultraviolet TV to Monitor Action in Human Cells

NEW YORK, N. Y.—A new application of closed-circuit television enables immediate comparison of chemical activity in live normal cells and others attacked by cancer. An RCA ultraviolet TV system is being used with a high-power microscope and an electronic oscilloscope to obtain direct observations and oscillographic measurements of cell metabolism.

The system introduces these advances in cell research:

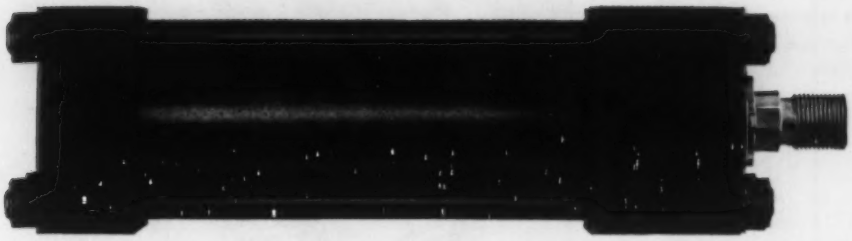
1. For the first time, it enables researchers to observe and take motion pictures, simultaneously, of chemical activity within living cells.
2. It makes possible microscopic study and analysis of hundreds of living cells in only a fraction of the time formerly required.
3. It makes possible direct observation and rapid, accurate measurement and identification of certain chemical changes within the cells.

Ultraviolet rays are absorbed in specific and measurable quantities by different chemicals. This characteristic enables the medical re-



BIGGEST BROACH, this 50 ft long, 150,000-lb machine has a 240-in. stroke. Developed by Lapointe Machine Tool Co., the electromechanical drive horizontal broaching machine broaches "pine tree" holding slots in the periphery of gas turbine wheels. It makes a slot 1.6-in. deep and up to 5 in. rim thickness. Each slot is broached in two passes. Variation in diameter of wheel broached on the machine's indexing fixture is from 40 to 80 in., and 30 to 150 slots can be made. The broached form is held to within a tolerance of 0.0003-in.

RUBBER CYLINDERS CARRY FLUIDS in a new method of off-the-road transportation. Collapsible Sealdbins, made of reinforced synthetic rubber by United States Rubber Co., are being tested by the Army Transportation Corps for transporting fuel. This Rolling Fluid Transporter, which can be towed on level ground by an Army Jeep, carries 500 gallons in each of six cylinders. The cylinders are centered on axles and connected to a towing yoke. This method of bulk fuel movement is said to work well in desert and arctic areas.



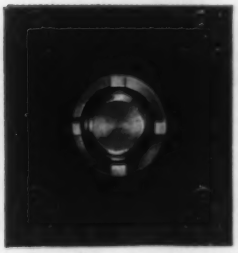
designed for leadership!

The superiority of Hannifin cylinders begins on the drawing board, where Hannifin designers have originated feature after feature not found in other air and hydraulic cylinders. But it doesn't end there...

Hannifin offers more kinds of cylinders, more sizes, more mounting styles. Each manufactured with such exacting control of dimensions and finishes that it not only looks like a better cylinder—its performance proves it!

As more and more discriminating specifiers and buyers are finding, the extra quality you get from Hannifin costs you no more, can usually be delivered sooner.

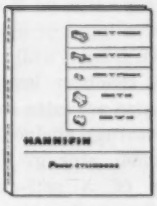
Why not specify Hannifin by name when you buy?



AIR AND HYDRAULIC

HANNIFIN

POWER CYLINDERS



Write for your copy of this new Hannifin Cylinder File—complete, easy-to-use, easy-to-order-from information on five lines of Hannifin cylinders. Hannifin Corporation, 515 South Wolf Road, Des Plaines, Illinois.

Circle 408 on page 19

searcher to identify several cellular chemical substances by measuring their ultraviolet absorption ratio. It is also possible now to introduce foreign chemicals and study their reaction with the cell's normal chemicals. Ultraviolet exposures can be kept as serial studies of disease-suspected cells and tissues.

In its present stage of experimentation, RCA considers the system a developmental technique, but one which holds important implications for future medical research. It offers significant possibilities also as diagnostic medium.

Experimental Kitchen Features Remote-Controlled Appliances

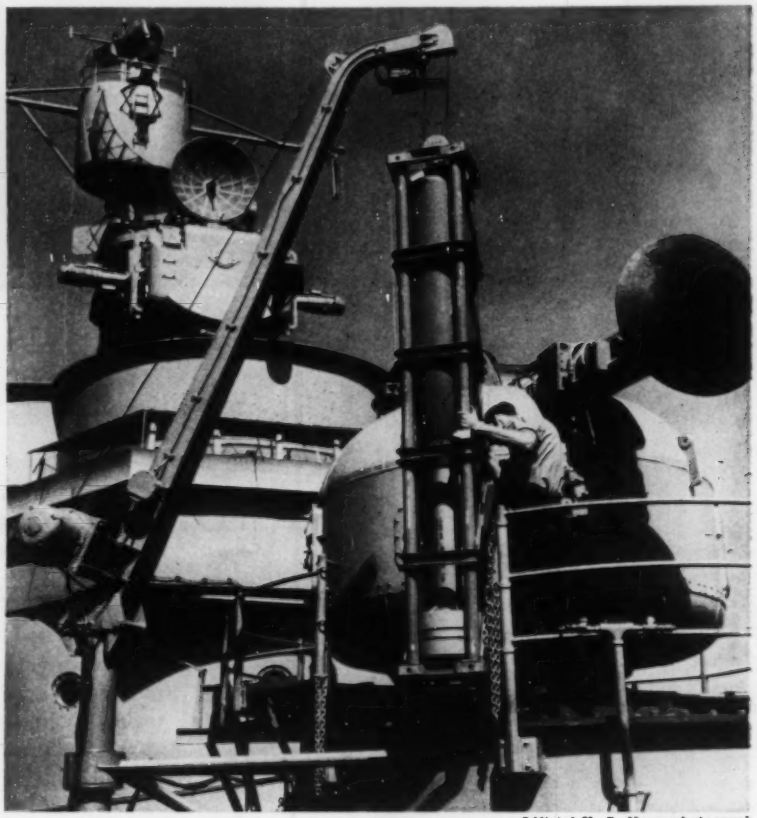
ST. JOSEPH, MICH.—A kitchen filled with mechanical gadgets, many of which operate by remote control, is the project of Whirlpool-Seeger Corp. engineers. This "RCA Whirlpool Miracle Kitchen" is designed to demonstrate projects that are in various stages of development in the engineering and research laboratories.

A self-propelled serving cart will detach itself from a dishwashing mechanism in the wall and deliver complete service to a dining table. After dinner it will fetch the used dishes and scoot back to its niche to dispose of waste and wash the dishes. Dispatched by remote control, a mobile floor cleaner scrubs the floor, then disappears into a base cabinet to recharge itself with washing agent and water for the next cleaning operation. It also waxes and polishes. Both the dishwasher and the floor cleaner are powered by batteries that are automatically charged when the units are in their respective wall niches.

The wave of a hand brings a refrigerator down from a wall cabinet to convenient reach-in level. The same gesture also actuates the lowering of food storage shelves, opening of a utensil storage drawer and dropping of a self-cleaning mixing unit from wall cabinet storage to the counter.

Food, beverage and ice storage and dispensing units are located at convenient work centers in the kitchen. A new cooling method, "piped cold," takes care of all refrigerated compartments from a central cooling unit.

Other equipment in the "Miracle Kitchen" includes a "meal maker" that moves selected prepared foods from cold storage to cooling, warming or cooking compartments; electronic oven and electronic grill; a rotating TV monitor that shows activity in other rooms of the house or receives standard broadcasts; and—a boon to the new bride—a canned food dispenser that will deliver a can intact or open, empty it automatically, and destroy the can.



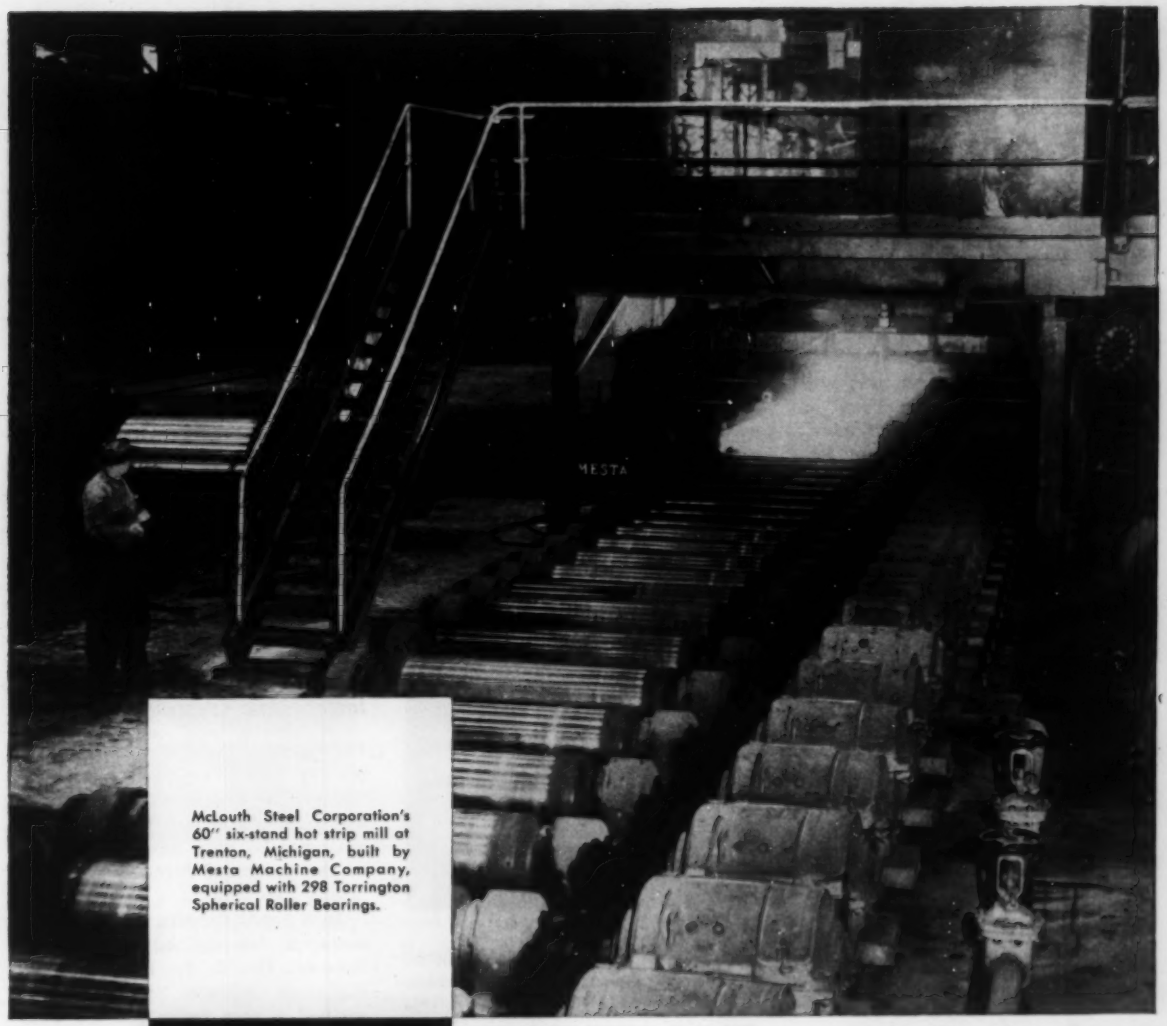
Official U. S. Navy photograph

WEAPON "ABLE" is this new antisubmarine rocket shown hoisted to its launcher on the Navy's destroyer leader *Wilkinson*. The missile weighs about 500 lb and provides an explosion equal to a conventional depth charge. The launcher rotates in almost a complete circle. It permits attack to begin at a distance and as soon as contact with a target has been established. The ship need not turn and race toward the target as with conventional depth charges. These features and the ability to vary the range of the rocket give ships equipped wih Weapon Able more control of more ocean.

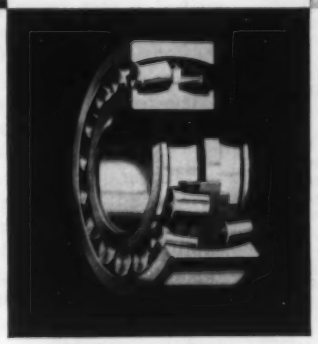
Neutron Beams to Expand Study of Crystal Structures

PITTSBURGH, PA.—A beam of neutrons is used in a new technique, developed by Westinghouse, for taking pictures of the atomic structures of metals and other crystalline materials. The process is claimed several hundred times faster and more sensitive than previous methods. It promises to yield important new information about the atomic architecture of crystalline materials.

Crystal structures dictate metal properties such as strength, brittleness and magnetic behavior. For



McLouth Steel Corporation's 60" six-stand hot strip mill at Trenton, Michigan, built by Mesta Machine Company, equipped with 298 Torrington Spherical Roller Bearings.



Self-driven table rolls mean drastic cut in mill down time!

It was a new idea. Suppose mill approach and runout table rolls had their own independent motors and pillow blocks instead of conventional gearing and line shafts? Then any roll could be removed for maintenance and replaced immediately by a stand-by assembly without shutting down the whole table for hours!

Torrington engineers, working with Mesta engineers, came up with a design mounting Torrington Spherical Roller Bearings in Torrington-built fixed and floating pillow blocks. These bearings compensate for misalignment across the table and for dynamic deflection of the rolls under load. In both roughing and finishing mill tables, 298 Torrington Spherical Roller Bearings have been operating efficiently since 1954!

The Torrington Company, with experience in the manufacture of every major type of anti-friction bearing, has made thousands of installations in steel mill equipment that have helped roll record tonnages. Your Torrington engineer is an expert: call on him when you need help. *The Torrington Company*, South Bend 21, Ind. – Torrington, Conn.

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District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Circle 409 on page 19

years, X-rays have been used to probe crystal structures. In passing through a crystal, the rays are diffracted by the crystal atoms, then allowed to fall on a photographic film. The photo pattern indicates the crystal's atomic arrangement.

More recently, with the advent of nuclear reactors, it was found that a beam of neutrons is diffracted in a similar fashion. It was also found that neutrons will reveal the crystal structure of many thousands of different materials which are impossible or impractical to analyze by X-rays.

Until now, however, there has been considerable difficulty in getting a satisfactory picture of the diffracted neutrons. Exposures of many hours are required with standard sources of neutrons. The new technique shortens this exposure time as much as 100 times and is expected to extend considerably the usefulness of neutron diffraction.

After being "scattered" by a crystal, the neutrons are allowed to strike a special fluorescent screen placed next to the film. The screen is made by imbedding a phosphor in a thin layer of special glass or plastic which contains atoms of boron. The neutrons pass through the photographic film and strike the screen, where they smash into the boron atoms. This releases tiny, powerful atomic particles which cause flashes of light on the screen. The flashes are recorded on photographic film.

Conversion of the neutron's energy to visible light is necessary because standard photographic film is "blind" to neutrons. The increased sensitivity and speed of the process over previous methods is due to the more efficient conversion of the neutron's energy.

The new technique should expedite the analysis of crystals of magnetic and organic materials particularly.

New Packard Clipper Has Supercharged Engine

SOUTH BEND, IND.—The 1957 Packard Clipper features a supercharger and automatic transmission as standard equipment. The supercharger, Flightomatic transmission and a new 3.31 to 1 rear axle ratio are credited with 15 per cent improvement in passing and acceleration over the 1956 model.

The Clipper's new engine is rated at 275 hp. The car has finned brake drums which are said to increase cooling area 100 per cent and brake life up to 30 per cent.

A new suspension system combines stiff springing action for rough roads and softer spring for smooth streets.

Styling of the Clipper has lowered the sedan 2 in. and reduced its weight by 300 lb. Besides the four-door sedan, a four-door station wagon is available, the first in this body type since 1950.

Available as optional equipment on the Clipper is a Twin-Traction safety differential which automatically compensates for muddy or slippery roads. It transfers most of the driving power to the rear wheel with the best traction. Other optional equipment includes power brakes, steering and windows; air conditioning; electrically operated radio antennas; and rear radio speaker.

Engine Specifications

Type	OHV, Vee
No. cyls.	8
Bore & stroke (in.)	3 13/16 x 3 5/8
Displ. (cu in.)	352
Comp. ratio	7.5 to 1
Bhp, max (supercharged)	275 @ 4800
Torque, max (lb-ft)	333 @ 3200

Size

	Four-door Sedan	Station Wagon
Wheelbase (in.)	120 1/2	116 1/2
Length (in.)	211.8	204.8
Width (in.)	77 3/8	77 3/8
Height (in.)	60	60 3/8

Metal Whisker Tests Measure Interatomic Crystal Forces

PITTSBURGH, PA.—Highly pure and perfect metal crystals known as "whiskers" are enabling scientists at the Westinghouse Research Laboratories to gain new information of the enormous forces which bind atoms together.

In a paper for the American Association for the Advancement of Science, Dr. R. L. Eisner, Westinghouse research physicist, described a new technique for evaluating these forces by measuring the tensile strength of whiskers of iron and silicon.

The technique is one of the most accurate methods known for pulling apart the tiny crystals and measuring directly the applied stress and the amount of strain they undergo. Precise, delicate equipment is required because the tiny strands of metal may be 40 millionths-in. or less in diameter.

"Any ordinary piece of metal contains countless millions of structural imperfections," Dr. Eisner said. "Under stress, it is these imperfections which govern how and when the metal will break. They mask any attempt to measure the much larger forces which hold the metal atoms themselves together.

"By conducting tensile tests on whiskers, where these imperfec-

tions do not exist, we can pull the individual atoms far enough apart, without breaking, to get a measure of the interatomic forces. This enables us, for the first time, to check modern theories of interatomic forces."

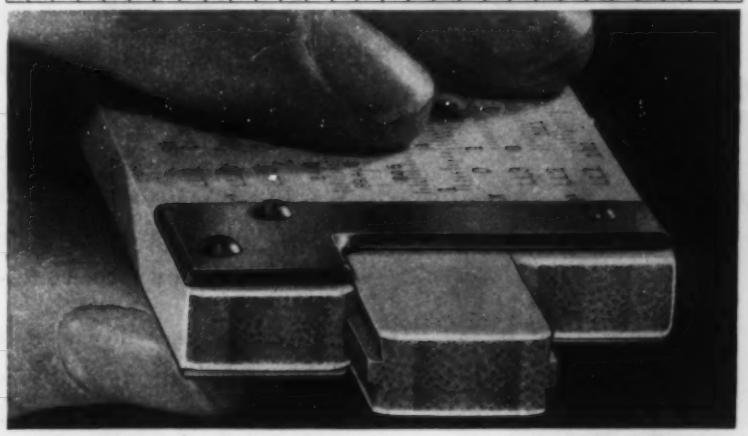
In the whisker experiments, a force less than 0.01-oz is required to pull the average whisker apart. This force, which must be controlled and measured with unusual accuracy, is obtained by a light-weight pendulum about 12 ft long. The whisker is clamped between the bob of the pendulum and a special "take-up" screw. As the screw is tightened, the whisker pulls the pendulum from its vertical position. Each millionth-oz of pull displaces the pendulum the same amount—about 0.0001-in.

Elongation is measured by reflecting a beam of light from flat optical mirrors attached to the clamps at each end of the whisker. The reflections form an interference pattern. As the whisker stretches, the mirrors move and cause changes in the pattern similar to the changing rainbow colors seen in soap bubbles or thin films of oil. These changes are electronically amplified and analyzed

(*Continued on Page* 22)

E IS FOR EDSEL, which will bear this plastic and metal hood ornament on the 1958 models. Other details of the automobile's appearance are still secret. Ford says the Edsel will be "advanced in style but not radical."

DRAFTING TRENDS



Magnified view of the laminated bamboo construction used in Post slide rules.

Why the trend to bamboo construction?

Due to its unique characteristics, bamboo is an especially suitable base material for various unusual applications. For example, experience over many years has proven bamboo's properties are ideal for slide rule construction. Here are some of the most outstanding reasons why the growing trend is to bamboo rules:

Bamboo gives smoother operation

Slide rules of other materials often require use of lubricants to insure smooth sliding. Bamboo avoids messy additives because it has natural, sealed-in silica particles that provide *self-lubrication*. The longer you use a bamboo rule, the easier it is to operate.

Bamboo holds its dimensions, retains its accuracy

Even in hot, humid weather, laminated bamboo slide rules resist expansion better than any other material. This dimensional stability assures consistently accurate readings.

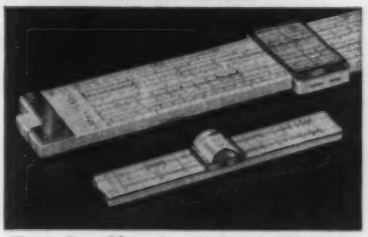
Recognizing the advantage of bamboo, Post uses it exclusively for slide rule construction. To the basic advantages of bamboo, Post has added several other features that further improve slide rule accuracy and dependability. For example, graduations are "engine-divided." Every marking is cut into the snow white celluloid face with a machine controlled knife edge. "Engine-divided" scales are easy to read, unfailingly accurate and last the lifetime of the rule.

Even the metal bound cursor on Post slide rules is designed for accuracy. A tiny, hidden spring keeps a perfectly vertical hairline.

Recent slide rule advancement

The latest development in bamboo slide rules was the introduction of Post's Versalog rule five years ago. This precision instrument meets the exacting demands of modern research, engineering and design. It features greater accuracy (four times greater in square root determination), color coding of trigonometric scales, new end zone designations for faster and surer computations, and more convenient arrangement of LL scales.

Probably the handiest bamboo slide rules made are Post's Vest Pocket rules. One has a 5" scale, the other a 4" scale with a magnifier as standard equipment. They are perfect for fast, spur-of-the-moment calculations.



(Top) *Post Versalog slide rule* (Bottom) *Post 1441 Vest Pocket slide rule*

For a free catalog describing Post bamboo slide rules, see your Post dealer or write today to the Reader Service Division of Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

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We are specialists in the custom-building of the types of gears shown here. We make them in quantity to your specifications.

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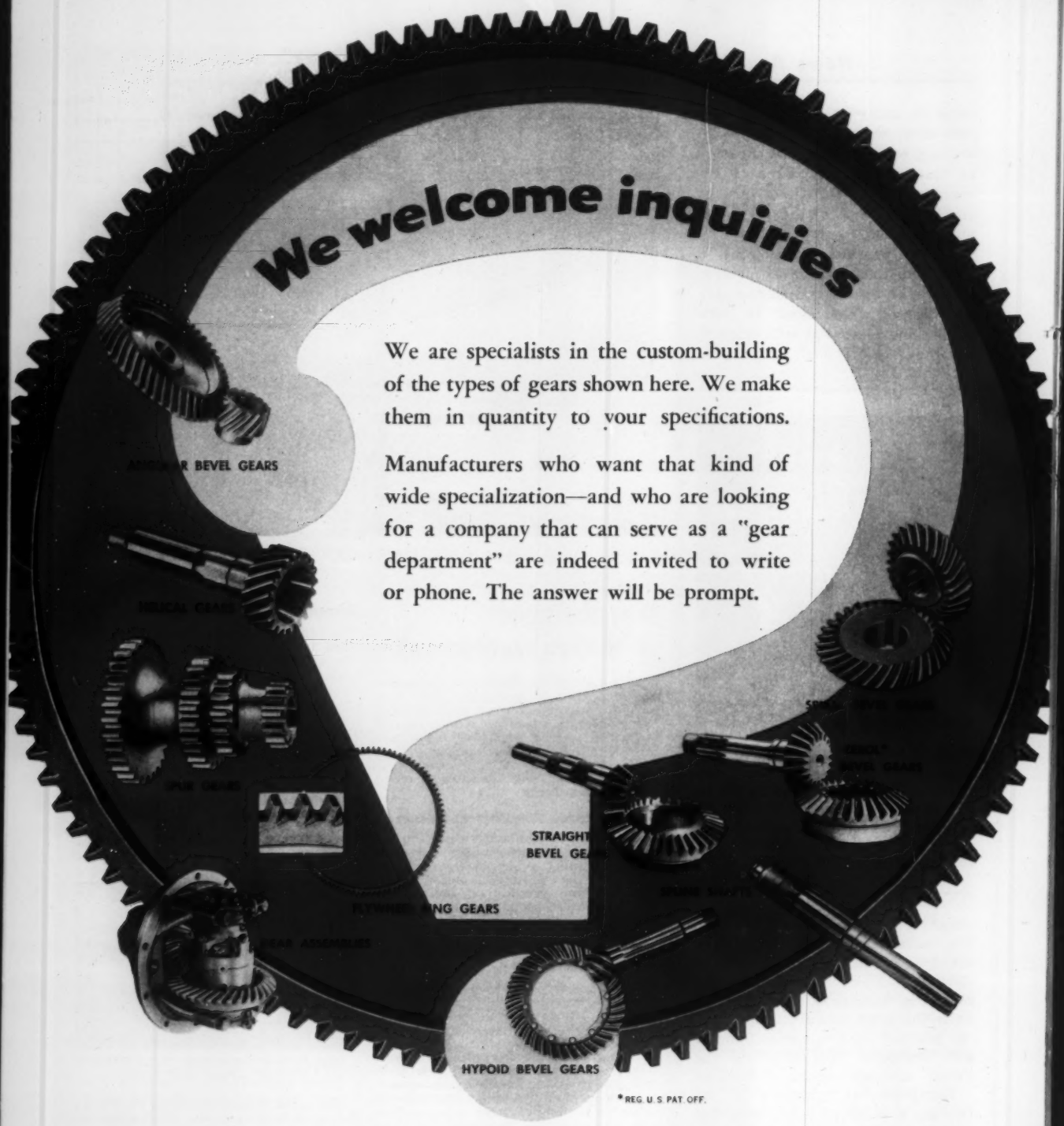

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GEAR-MAKERS TO LEADING MANUFACTURERS

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407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
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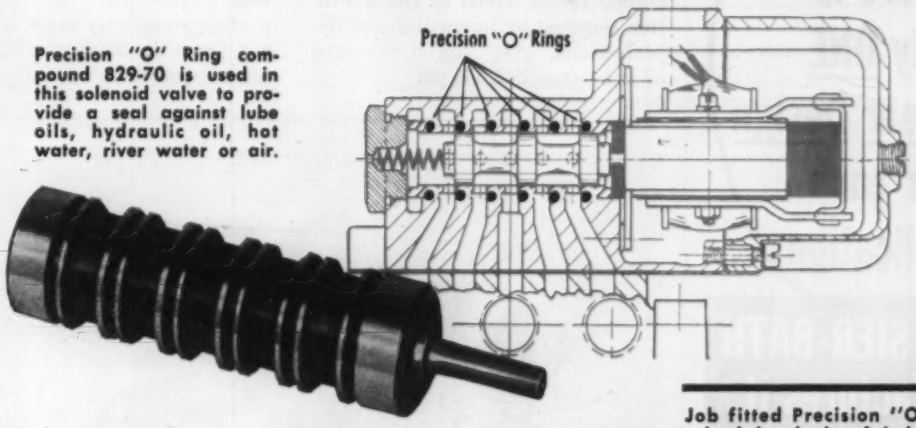
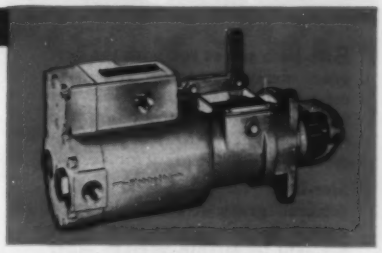
COMPOUND 829-70

Versatile PRECISION "O" RING fills sealing requirement in dozens of industrial products

Precision "O" Ring compound 829-70 is used in this solenoid valve to provide a seal against lube oils, hydraulic oil, hot water, river water or air.



Job fitted Precision "O" Rings have solved hundreds of industrial, aircraft and automotive sealing problems.

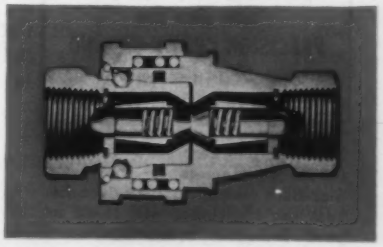


Precision "O" Rings were selected for this cranking motor after exhaustive tests for flexibility and sealing in arctic cold.

Uniformity of size, excellent surface quality, compatability with a wide range of fluids . . . Numatics, Inc. of Milford, Michigan, cite these as reasons why "O" rings made from Precision Compound 829-70 are being used in their solenoid valves. They are giving service through more than 30,000,000 valving actions.

Hundreds of Precision "O" Ring compounds are meeting the exacting requirements of industry. Modern pre-testing methods and engineering skill assure dependable, long life service. They are compression molded — rigidly inspected — meet all military and commercial specifications — the finest made! At Precision, you'll find "O" rings in sizes and compounds to meet your requirements.

What is your sealing problem? There is an expert — the Precision engineer — ready to help you in product design and "O" ring specifications. You can rely on him — and on Precision, the world's largest exclusive producer of "O" Rings.



In this coupling, an "O" ring made from Precision Compound 829-70 seals against hydraulic fluids and pneumatics.

Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals

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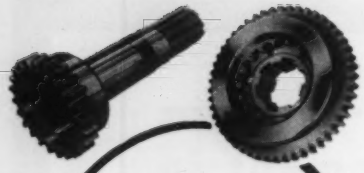

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—all materials
Made—cut—shaved—ground tooth
48" maximum diameter
12 or more of a kind, depending on size

Circle 413 on page 19

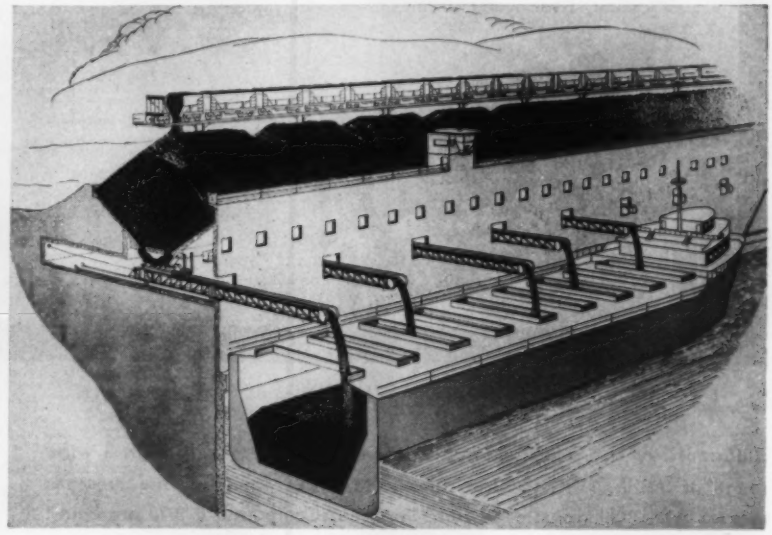
Engineering News Roundup

(*Continued from Page* 15)

to disclose the amount of stretch. The technique accurately measures changes less than 1 millionth-in. in whisker length.

According to Dr. Eisner, the experiments have revealed that interatomic forces, freed of the limitation imposed by impurities and imperfections, give iron a strength of more than 500,000 psi.

"Whereas in ordinary steel the imperfections cause it to flow and deform at one-tenth its ultimate strength," he said, "we have found no such plastic deformation when interatomic forces only are involved. Even the elastic limit of soft metals such as tin in the perfect structural state is at least ten times the maximum in the best steels in common use today."



BELTS FOR PELLETS are the feature of this new ore loading system soon to operate at Taconite Harbor, Minn. First of its kind used with ore boats, the Link-Belt conveyor system permits loading of 10 alternate hatches simultaneously. Taconite pellets are weighed as they travel the belts. Total of 25 belts are operated from a central control tower. Each belt handles 750 or 1500 long tons per hour at belt speeds of 250 or 500 ft per minute.

Launching Will Be Acid Test For Vanguard Instruments

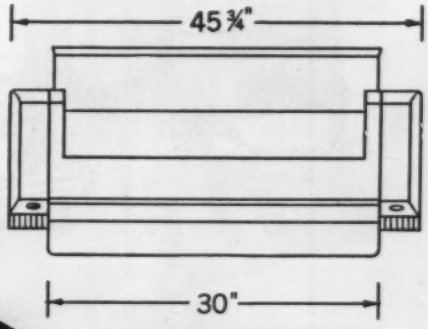
Harsh Operating Conditions Include Extreme Temperatures

PHILADELPHIA, PA. — Instruments in the earth satellite launching rocket, Vanguard, will be required to make precision measurements while exposed to liquids and gases corrosive enough to etch most types of steel. The instruments must also withstand temperatures ranging from 900 F to −300 F. These operating conditions were revealed recently by Vernon J. Crouse, a group engineer at the Martin Co. in charge of the design of instrumentation and telemetry systems for Vanguard flight tests.

A flight test program will precede the satellite launching scheduled for the International Geophysical Year, July 1, 1957, to December 31, 1958.

Each test vehicle will carry an instrumentation system capable of making between 150 and 200 different measurements. The number and type of measurements will vary with each vehicle, but they will include such items as liquid and gas pressures, voltages and currents, temperatures, strains and acceleration. As many as four separate telemetering transmitters will be used in each test vehicle to radio

At Last! A Small Whiteprinter that Makes BIG Prints!



FULL 30-INCH PRINTING WIDTH!

NEW! BRUNING Copyflex Model 300!

Brings "Inside" Reproduction within the Means of the Smallest Engineering Firm or Department!
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The new Copyflex Model 300 is ideal for drafting rooms and offices because it can be operated anywhere without annoyance to personnel in the vicinity. It is clean, quiet, and odorless. No exhaust venting, plumbing, or accessory equipment required. It needs only a connection with a 115-volt AC outlet for operation.

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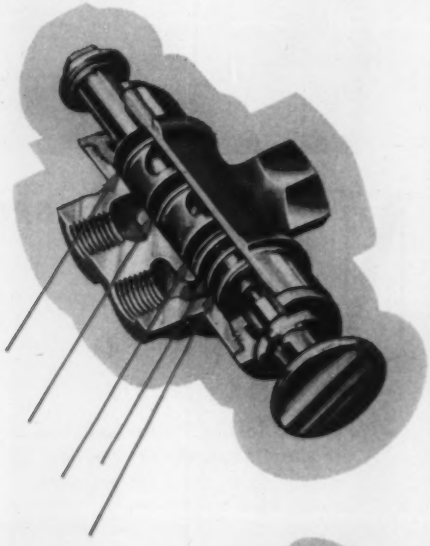
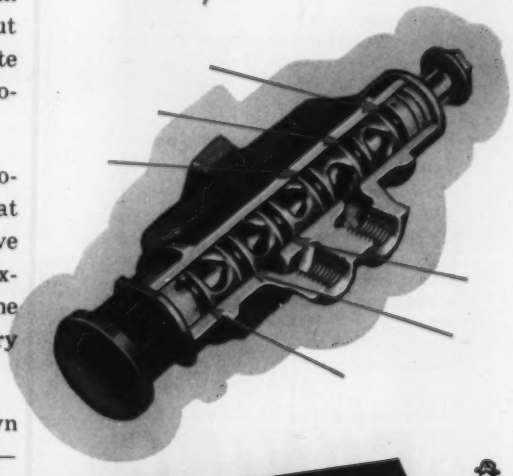
meet demands of newest valve design with precise sealing ability ... complete dependability



You see them everywhere—small valves that work under high pressures, all-important control links in new hydraulic and pneumatic systems. They're vital in industry's new trend to automation.

There's one design problem common to almost all these valves . . . getting a seal that's tight, dependable and long wearing, yet allows free valve movement for precise and rapid operation and control.

It's a tough problem, but there's a quick and easy answer in Houghton Vix-Syn "O" rings and packings. You can put them into the most demanding valve designs with complete assurance of dependability, high efficiency in sealing, economy, and long, trouble-free service life.



Houghton developed synthetic rubber specifically to provide design engineers with "O" rings and packings that match the requirements of the newest, most modern valve designs. Call on Houghton, too, for specially molded Vix-Syn parts and compounds. You'll be served by the same packing specialists who set the packing standards industry everywhere uses today.

Ask your Houghton Man for the full story of how Vix-Syn takes the problems out of valve design. Call him today—or write E. F. Houghton and Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

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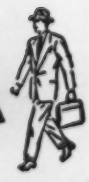

Ready to give you on-the-job service . . .

Circle 415 on page 19

this data back to ground stations.

As prime contractor for the Vanguard, the Martin Co. has subcontracted the development of the instrument systems. Participating instrument makers include Rahm Instrument Co., Bendix-Friez Instrument Div. of Bendix Aviation Corp., and Aero Research Instrument Co.

Experience gained with the research rocket Viking is helping Martin to solve problems of monitoring the pressure and temperature of liquid oxygen and hydrogen peroxide. These are used as oxidizing agents in Vanguard.

Concentrated hydrogen peroxide is highly explosive itself, and liquid oxygen reacts with plastics and other organic materials to make them explosive. Furthermore, liquid oxygen boils at approximately −300 F which accounts for the very low temperatures to which Vanguard instruments will be subjected. The high temperatures to be encountered are due to air friction and engine heat.

Some of the fuels to be used in

Titanium Topics

Successful deep drawing of titanium alloys has been announced by Worcester Pressed Steel Co., which has completed a two-year research program for the U. S. Army Ordnance Corps. Deep drawing was accomplished with four alloys in which titanium was combined with manganese, aluminum and tin, aluminum and vanadium, and manganese and aluminum. Titanium alloys, heretofore believed unsuitable for stamping because of their working properties, can now be fabricated by mass-production methods. Previously, only pure titanium had been successfully deep drawn.

• • •

A new chemical descaling process for titanium and its alloys requires only two immersion steps—one for scale conditioning and one for scale removing—and two rinsing steps, following the heat forming or heat treating operation. The process, announced by Turco Products Inc., does not adversely affect physical and chemical properties of the metal. It requires relatively low temperatures of 270 to 280 F and results in metal loss of only 0.0001 to 0.0003-in. per side. Hydrogen pickup and the resultant hydrogen embrittlement are avoided.

• • •

A solid titanium "head" has been formed w' ut the use of dies and stampi. ; equipment. Head shapes, used in a variety of industrial equipment to close up the ends of cylinders, previously were made only with dies which had to be built individually for each variation in size and shape. In a research program conducted by Lukens Steel Co. and Rem-Cru Titanium Inc., a preheated titanium plate was placed on a spinning machine and worked at a minimum temperature of 600 F. Standard equipment was used to spin an elliptical shaped head 16 in. in diameter and ¼-in. thick.

• • •

A Titanium Conference will run concurrently with the Western Metal Congress and Exposition, March 25-29 in Los Angeles. Lectures and panel discussions will cover forming, machining, welding and brazing, and a look into the future of titanium. Details of the conference are available from headquarters of the American Society for Metals, 7301 Euclid Ave., Cleveland 3, O.

• • •

Production of finished titanium mill shapes totaled 10,600,000 lb in 1956, according to a report from Titanium Metals Corp. of America. This required about 23 million lb of ingot metal, 20 million lb of which was the pure basic raw material, titanium sponge, and 3 million lb alloy additions and recycling of titanium scrap. The report also stated that production goals for 1957 represent a 135 per cent increase over 1956. About 23 million lb of mill products are scheduled for delivery this year. Although all commercial producers of titanium sponge continue to use either magnesium or sodium as reducing agents in the extractive process, the industry continues to seek a new, "very low-cost" extractive procedure.

Miniature Pressure Transducers for operation to +400°F.

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When the transducer is a Statham, pressure measurements at elevated temperature are made with accuracy and confidence.

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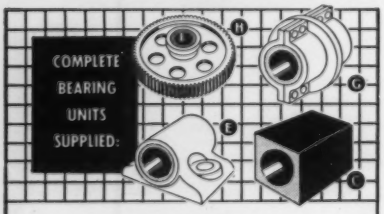

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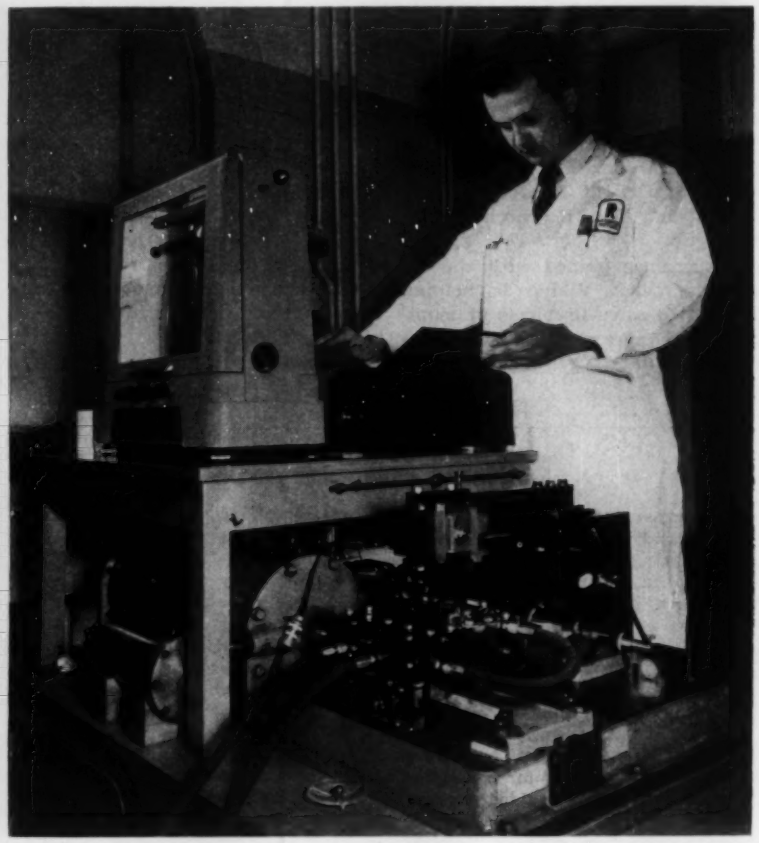

WHAT MAKES ROLLING THINGS STOP is the subject of investigations to be performed on this new apparatus designed by Richard Drutowski (above) of G-M Research Staff. The equipment will measure the effect on rolling friction of such variables as the materials of a ball and surface, their roughness and hardness. Rolling friction in new products will be calculated.

the satellite launching vehicle raise other problems. White fuming nitric acid, for example, will be used as a fuel in the second stage engine. This acid corrodes most metals in a relatively short time.

One of the basic instruments designed by the Rahm Co. to operate in contact with such substances is a specially welded stainless-steel bourdon tube. The fluid is introduced directly into the C-shaped tube. The whole tube is jacketed by a fail-safe stainless steel case for extra protection.

To measure outer surface temperatures, Vanguard will carry platinum wire grids cemented to bits of foil the size of postage stamps. The foil is spot-welded directly to the rocket body.

Thermocouples, strain gages and other types of measuring devices which require complex circuitry have been ruled out wherever possible. Instead, most Vanguard instruments will use potentiometric sensing elements which make measurements by recording changes in electrical resistance. Output voltage of instruments and transmitters can be the same.

Air Springs Used on Cadillac Eldorado Brougham

NEW YORK, N. Y.—The first air springs to be used on an American passenger car will cushion the ride of the 1957 Cadillac Eldorado

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MONTGOMERY CO., PA.

Circle 419 on page 19

Brougham.

The tire division of United States Rubber Co., producer of the new springs for the Brougham, claims that air springs provide "the most comfortable ride in the history of the automobile." The company predicts general use of air springs in automobiles by 1960.

The air spring is a rubber and nylon fabric diaphragm which is fitted onto the open end of a metal air tank and held in place by air pressure. One spring is used at each wheel. A metal piston for each diaphragm, self-regulating air valves and an air compressor are included in the system.

This spring also promises a means for reducing height of cars without decreasing ground clearance. The body of a car equipped with air springs can be set lower on the axles, since height of the body above the axles is not affected by weight of the load.

Meetings

AND EXPOSITIONS

Feb. 24-28—

American Institute of Mining, Metallurgical and Petroleum Engineers. Annual Meeting to be held at the Hotel Jung, New Orleans. Additional information can be obtained from the institute's headquarters, 29 W. 39th St., New York 18, N. Y.

Feb. 25-March 1—

American Society of Heating and Air-Conditioning Engineers. 13th International Heating and Air-Conditioning Exposition to be held at the International Amphitheater, Chicago. Further information is available from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Feb. 26-27—

Third Conference on Radio-Interference Reduction to be held at Armour Research Foundation of Illinois Institute of Technology, Chicago. Further information can be obtained from the foundation, Technology Center, 10 W. 35th St., Chicago 16, Ill.

Feb. 26-28—

Western Joint Computer Conference to be held at the Statler Hotel, Los Angeles. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers and Association for Computing Machinery. Further information can be obtained from S. Dean Wanlass, Aeronutronic Systems Inc., 13729 Victory Blvd., Van Nuys, Calif.

March 5-7—

Society of Automotive Engineers Inc. National Passenger Car, Body and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

March 6-8—

Pressed Metal Institute. Annual Spring Technical Meeting to be held at Hotel Carter, Cleveland. Further information is available from institute headquarters, 3673 Lee Rd., Cleveland 20, O.

March 7—

Fourteenth Annual Machine Design Conference, sponsored by the Cleveland Engineering Society. Conference will be held at society headquarters, 2136 E. 19th St., Cleveland, O. Further information is available from Joseph H. Gepfert, Reeves Pulley Co., 6408 Euclid Ave., Cleveland, O.

March 11-14—

1957 Nuclear Congress and International Atomic Exposition, to be held at Convention Hall, Philadelphia. This second nuclear engineering and science conference, sponsored by 20 technical societies, is co-ordinated by the Engineers Joint Council. Further information can be obtained from the Council, 29 W. 39th St., New York 18, N. Y.

March 11-15—

National Association of Corrosion Engineers. Thirteenth Annual Conference and Exhibition to

Here at Headquarters you get the priceless advantage of 41 years' experience in mass producing better Small Gearing exclusively! Actually, we take in stride even the most intricate or unusual applications. We produce simpler designs by hundreds or thousands with a degree of accuracy and economy you never thought possible! ★ The special components pictured above feature a hobbed diamond knurl with sharp points at tips of teeth. RH and LH helix angle and pressure angle may be varied for different applications. This is only one of many special tooth forms that can be generated by the hobbing process. ★ Skilled G.S. Engineers will gladly lend you valuable aid on YOUR problems, too! Mail drawings and descriptions today.

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

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Specialties, Inc.
2635 WEST MEDILL AVENUE
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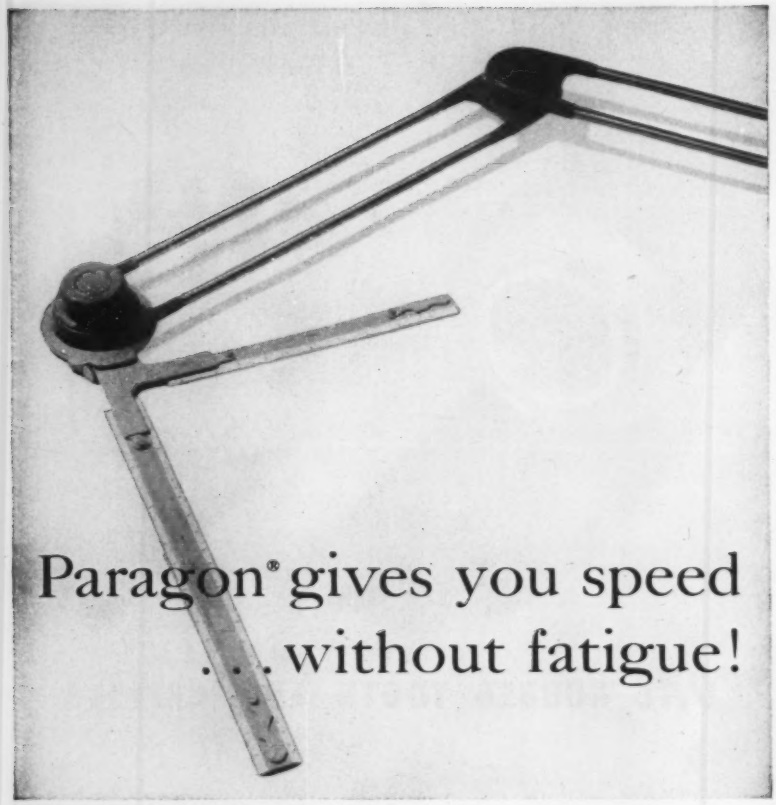
SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

FRACTIONAL HORSEPOWER GEARING

41 Years of Specializing in Small Gearing!

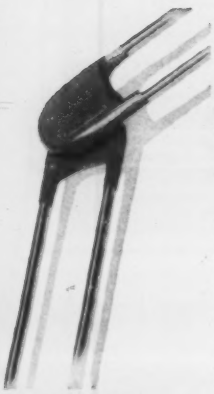
Circle 420 on page 19



Check the response-to-the-touch. You can actually feel the difference!

That's why the Paragon Drafting Machine noticeably cuts end-of-the-day fatigue . . . saves costly man hours . . . helps raise working standards.

See how easily protractor control ring can be reached—no matter what position your hand is in. Another time saver. Touch that ring with your *little* finger and scales rotate freely. Release pressure and scales automatically lock to nearest 15° position. And intermediate angles are just as easily set!



Top day-to-day performance is guaranteed by unique "open center" design of arms which protects smooth-working factory-set band tension.

A good look at a Paragon and a touch on that control ring is worth 1,000 words! Try it before you buy *any* drafting machine—you can *feel* the difference.

89 YEARS OF LEADERSHIP

In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

K&E **KEUFFEL & ESSER CO.**

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News Roundup

be held at Kiel Auditorium, St. Louis. Additional information can be obtained from association headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 13-15—

National Fluid Power Association. Spring Meeting to be held at Hollywood Beach Hotel, Hollywood, Fla. Further information can be obtained from association headquarters, 1618 Orrington Ave., Evanston, Ill.

March 18-19—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information is available from society headquarters, 606 Terminal Tower, Cleveland 13, O.

March 18-20—

American Society of Mechanical Engineers. Gas Turbine Power Conference to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

March 18-21—

Institute of Radio Engineers. National Convention to be held at the Waldorf Astoria Hotel, New York. Additional information can be obtained from institute headquarters, 1 E. 79th St., New York 21, N. Y.

March 18-21—

Society of the Plastics Industry Inc. Annual National Conference and Pacific Coast Plastics Exposition to be held at the Hotel Biltmore, Los Angeles. Further information can be obtained from society headquarters, 250 Park Ave., New York 17, N. Y.

March 20-22—

Society of Automotive Engineers Inc. Production Meeting and Forum to be held at Hotel Statler, Buffalo, N. Y. Further information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

March 25-27—

American Society of Tool Engineers Silver Anniversary Technical

Circle 421 on page 19

Meeting and Convention to be held at the Shamrock Hilton Hotel, Houston, Tex. Additional information is available from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

March 25-29—

Tenth Western Metal Exposition and Congress to be held at the Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles. Sponsors are American Society for Metals and other technical groups. Additional information is available from ASM headquarters, 7301 Euclid Ave., Cleveland 3, O.

March 27-28—

American Society of Mechanical Engineers-American Institute of Electrical Engineers Engineering Management Conference to be held at the Hotel William Penn, Pittsburgh. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

March 27-29—

American Power Conference, to be held at the Hotel Sherman, Chicago. The conference is sponsored by Illinois Institute of Technology in co-operation with 14 universities and nine national and regional technical societies. Additional information is available from conference secretary E. R. Whitehead, Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

While you're up there, find out if they've received the drafting machines yet.

If it's HOT or DRY

USE 'DIAMOND H' SERIES R RELAYS

Where the temperature hits 200°C. or the dry circuit is downright arid, your best bet for reliability is a "Diamond H" Series R miniature, hermetically sealed, aircraft type relay. Their shock and vibration resistance you may take for granted.

On the other hand, Series R relays (4 PDT) also give excellent reliability at —65°C. and will carry up to 10 amperes in power circuits . . . or even 20 amperes for short life requirements. In other words, they offer an extremely wide range of performance characteristics from which "Diamond H" engineers will be happy to work out a variation to meet your specific requirements. Just ask.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to +85°C. —65° to +125°C. —65° to +200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,000 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3 ms.
Contacts:	30 V., D.C.; 115 V., A.C.; 2, 5, 7½ and 10 A., resistive; 2 and 5 A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance—less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs —plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Bulletin R-250 gives more complete data. Send for a copy.

THE HART MANUFACTURING COMPANY

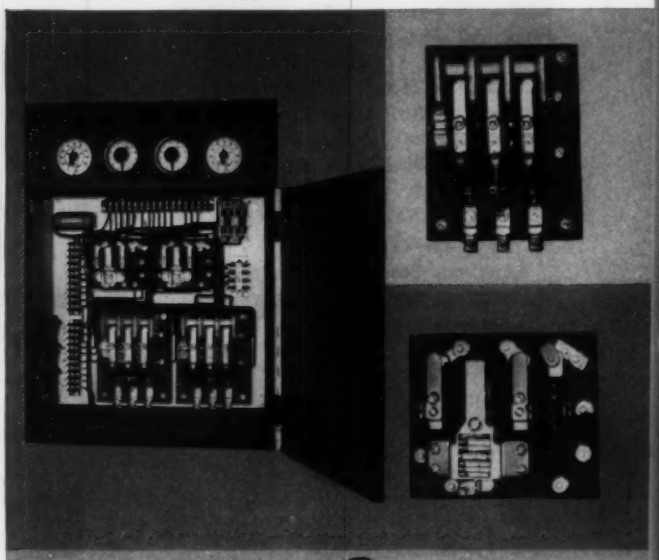
118 Bartholomew Ave., Hartford, Conn.

Circle 422 on page 19

50 precision shell molds per hour with ASCO CONTROLS

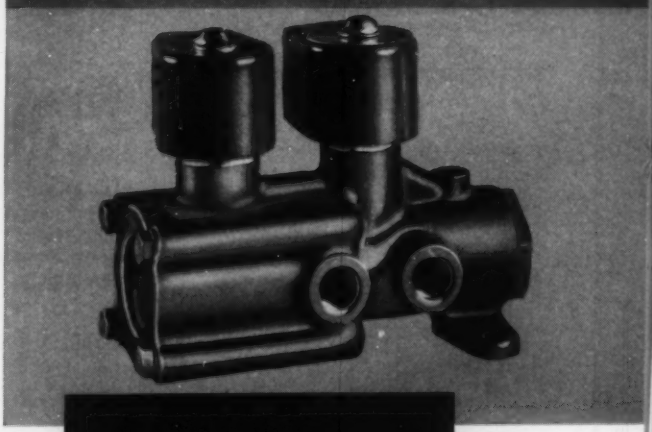
Dependable precision control by ASCO has been a long time feature of a wide range of automatic equipment and machine tools. A typical example is the Shell-O-Matic high speed shell molding machine shown here. The machine produces precision shell molds for casting in ferrous and non-ferrous metals. ASCO solenoid valves sequenced by ASCO relays completely control the operation.

Integrated in the control system are the ASCO control panel, single and dual solenoid valves with watertight molded coils, relays and contactors. These controls help Shell-O-Matic achieve a production rate of 50 precision units per hour.



ASCO CONTROL PANEL

This control panel consists basically of two ASCO 1054 Relays and 1035 Contactors. The 1054 is especially designed for rugged industrial use with powerful efficient magnet for positive action. It is a 25 ampere relay, available in a variety of pole combinations up to 12 poles. The Bulletin 1035 is a continuous duty contactor, suitable for all classes of load, with interrupting capacity of 6 times rated current. Standard ratings are to 300 amperes; contactors with higher capacities are available.



ASCO SOLENOID VALVES

ASCO Bulletin 8344 4-way solenoid valves are especially designed for double acting pneumatic or hydraulic cylinders. In this installation watertight luxolene molded coils have been specified since the shell molders are washed down frequently. These poppet type valves provide tight seating with absolutely no leakage. They are power driven in both directions by line pressure. A full line is available: sizes ⅜"– 1" with single or dual solenoids and J.I.C. construction.

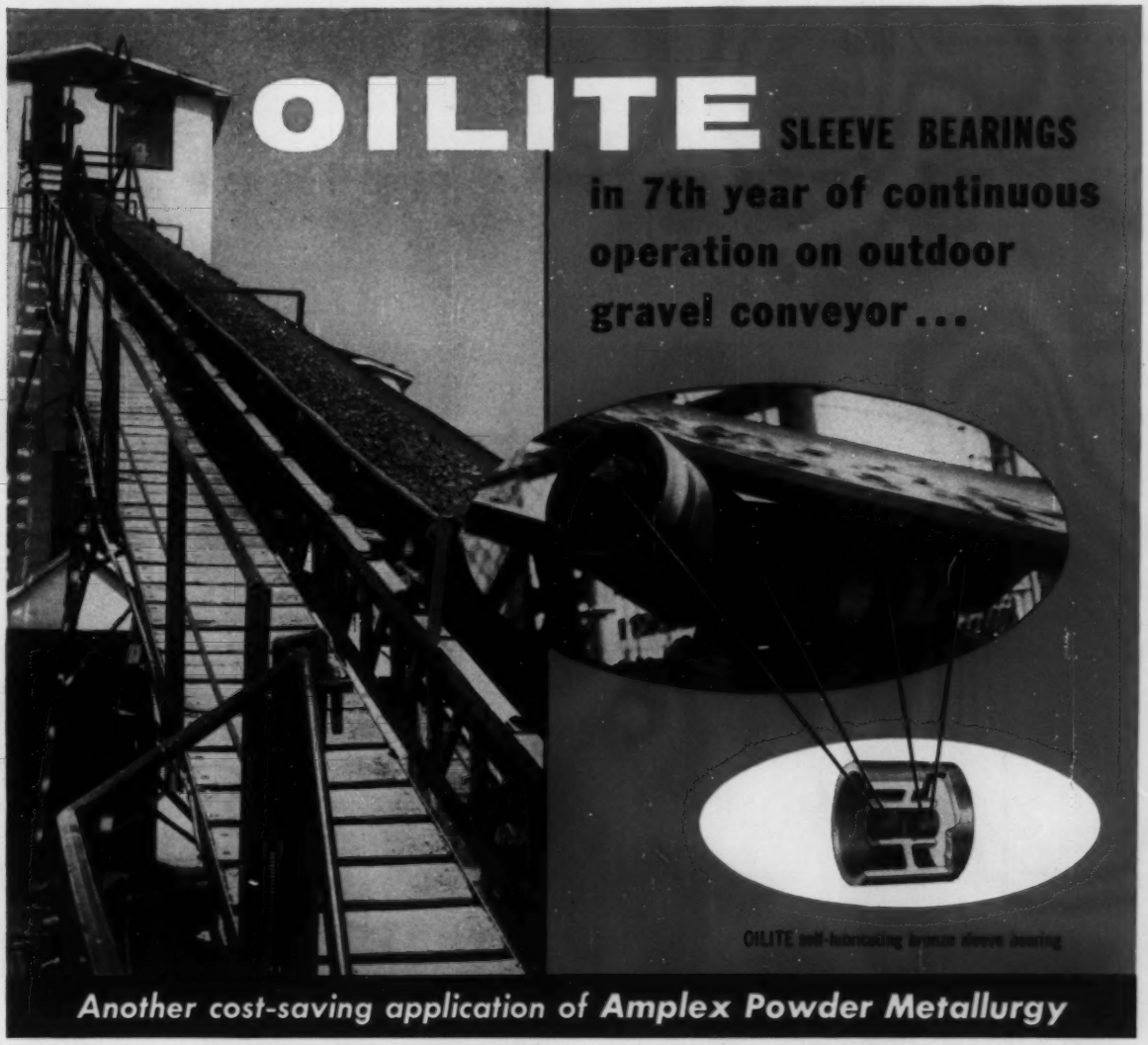
These quality products are representative of the complete line of ASCO controls now available. Design *your* control system with ASCO electromagnetic control and solenoid valves. Technical literature and engineering assistance are available. Write ASCO today about your control problem.

Automatic Switch Co.

54-A Hanover Road, Florham Park, New Jersey

ASCO®

Circle 423 on page 19


OILITE SLEEVE BEARINGS
in 7th year of continuous operation on outdoor gravel conveyor...
OILITE self-lubricating bronze sleeve bearing
Another cost-saving application of Amplex Powder Metallurgy

No seals protect these OILITE bearings from sand, gravel, grit. On the two center rollers, no additional lubrication is possible. Yet this OILITE-equipped outdoor conveyor has been in continuous operation under extreme weather conditions for seven years—*without replacing one OILITE bearing.*

That's some record! J. Cooke (Concrete Blocks) Ltd., of Aldershot, Ontario, one of Canada's largest producers of concrete blocks, operating twenty of these sand and gravel conveyors, has proved the long wearing, money saving qualities of OILITE bearings.

No wonder all twenty conveyors are 100% OILITE equipped. The company says, "We wouldn't use any other kind."

What interests you? Longer product life—greater efficiency—lower cost? All three? Maybe Amplex has the answer.

Write for detailed information about Amplex powder metal components—OILITE Bearings, Parts, Filters. Or call your nearest engineering representative listed in the yellow pages under "Bearings—OILITE."

Representatives and dealers located in principal cities in United States and Canada.

CHRYSLER OILITE PRODUCT

Only Chrysler Makes **OILITE**

AMPLEX DIVISION

CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

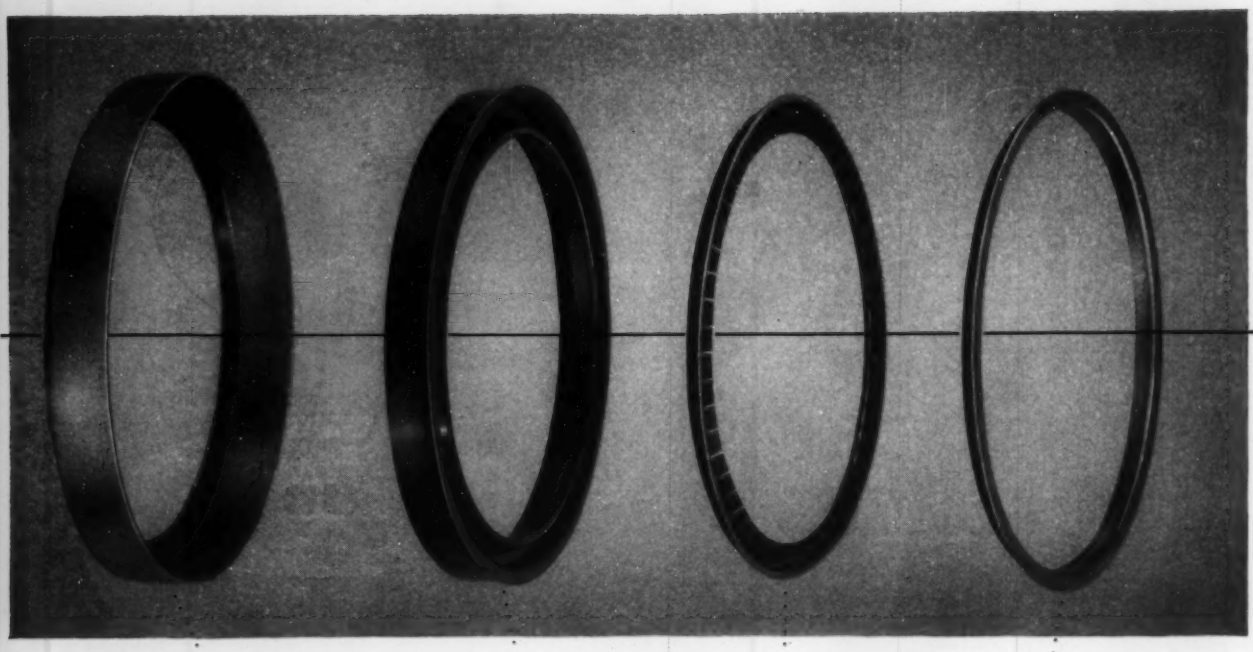
Bearings • Finished Machine Parts • Permanent Metal Filters • Friction Units

Ferrous and Non-Ferrous Metals

New 52-page OILITE Engineering Manual supplies engineering data and application information on OILITE powder metal bearings, parts and filters. Write on your letterhead for Manual E-56. Address: Dept. 8C.

MORE OF THE GARLOCK 2,000

Put 'em all together . . .



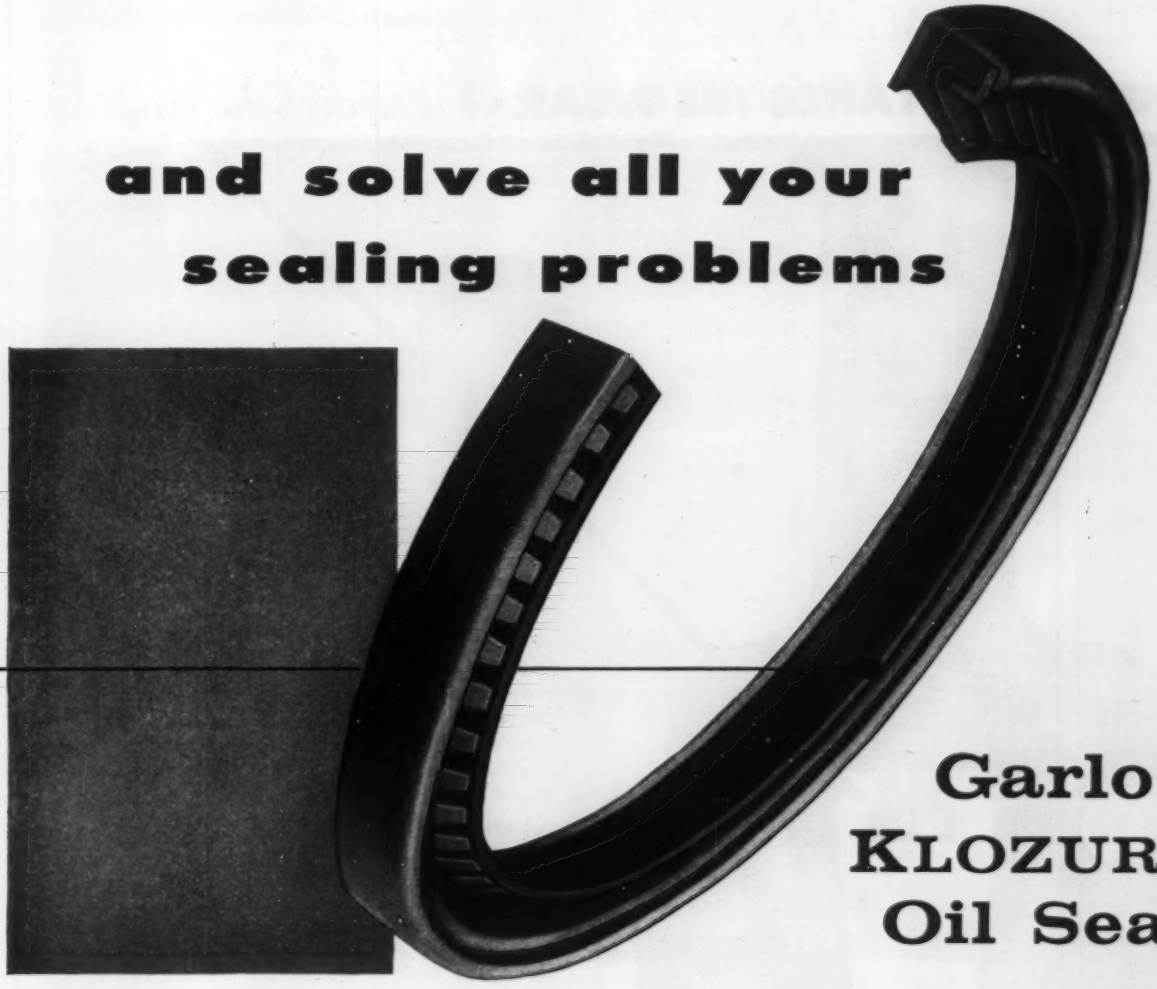
PRECISION FORMED CASE, held to ±.001" dia., has a polished smooth finish . . . no grinding is needed, therefore KLOZURE cases are of uniform thickness throughout, no thick-and-thin areas. Also, the danger of trapping grinding abrasives in the assembly is entirely removed.

THE FINGER SPRING is second only to the sealing element in importance. This one is a distinctive Garlock development which supplements the resiliency of the sealing element in Garlock KLOZURES. It is free to move with the sealing element, and is so precisely tempered that it retains its flexibility throughout the life of the seal. Other conventional springs are also available.

SEALING ELEMENTS in Garlock KLOZURE Oil Seals are made in a variety of shapes from Buna N, Polyacrylate, Silicone Rubber, or Teflon, depending on service conditions. For example, where extreme heat and high speeds are encountered silicone rubber may be desired. Where acids or other chemical conditions exist, Teflon may be desired. In any case, the dependability of the seal is largely determined by the design and construction of the sealing element. Therefore, Garlock offers a wide choice to exactly suit every job.

THE ADAPTER holds and locates properly the sealing element and spring in the metal KLOZURE case.

and solve all your sealing problems

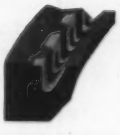


Garlock KLOZURE* Oil Seals

MODEL 53 for larger shafts under normal service

MODEL 71A Springless KLOZURE for excluding dirt or retaining grease

MODEL 63 for normal and high-speed service



Split KLOZURE for installation without disassembly of equipment

Every part of KLOZURE Oil Seals is engineered to give superior service on the job for which it is intended. Through the various combinations of sealing elements, springs, and cases, the proper KLOZURE Oil Seal can be developed for any requirement. Whether your sealing problem involves high shaft speeds or temperatures; corrosive liquids, synthetic fluids, or limited space . . . there is a Garlock KLOZURE Oil Seal to solve it. Why not investigate and see?

Remember KLOZURE Oil Seals are only part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. It's the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today, or write for KLOZURE Catalog.

*Registered Trademark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

Circle 425 on page 19

In JENKINS *Monel-seated Bronze Gates*

THE WEDGE* TAKES THE WEAR - *and spares the rings*

Easy replacement of the wedge only — right on the line — restores full efficiency

THE MONEL SEAT RINGS are expanded into the body to assure a positive, leak-proof joint. Exhaustive tests in typical monel-seated gate valve services show that this permanent all-around support of the rings is essential to guard against deforming, loosening, or shifting.

***THE RENEWABLE WEDGE** (bronze or nickel alloy) has excellent wear resistance, but has a lower degree of hardness than the heat-treated Monel rings, which have optimum resistance to erosion and corrosion as well as abrasion. Thus, wear of the wedge leaves the rings relatively unaffected. When necessary to renew the wedge, you simply remove the valve bonnet, slip the old wedge off the stem, and slip on a new one.

GET PRACTICAL, LOW-COST RENEWABILITY in the valves you choose for the tough, punishing services that require Monel-seated gates. Compare . . . there is nothing simpler, faster, or more economical than Jenkins replaceable wedge design — and you also get the *plus* of Jenkins *extra value* in every other feature. Jenkins Bros., 100 Park Ave., New York 17, New York.

***MADE WITH BRONZE OR NICKEL ALLOY WEDGE**

The bronze wedge provides lasting economy for most applications. The nickel alloy wedge provides extra resistance where rapid wear and corrosion are factors.

JENKINS BRONZE GATES WITH MONEL SEAT RINGS

200 psi	300 psi
Fig. 270-U, Bronze Wedge	Fig. 280-U, Bronze Wedge
Fig. 270-UN, Nickel Alloy Wedge	Fig. 280-UN, Nickel Alloy Wedge
Fig. 270-UL, Bronze Wedge, U.L. approved for L.P.G. Services	350 psi Fig. 280-UX, Bronze Wedge

JENKINS BRONZE GATES INCLUDE 40 DIFFERENT PATTERNS

125 • 150 • 200 • 300 • 350 psi SOLID WEDGE • SPLIT WEDGE
SCREWED • FLANGED • SOLDER END • SOCKET END QUICK OPENING

Call your local Jenkins Valve Distributor for complete information.

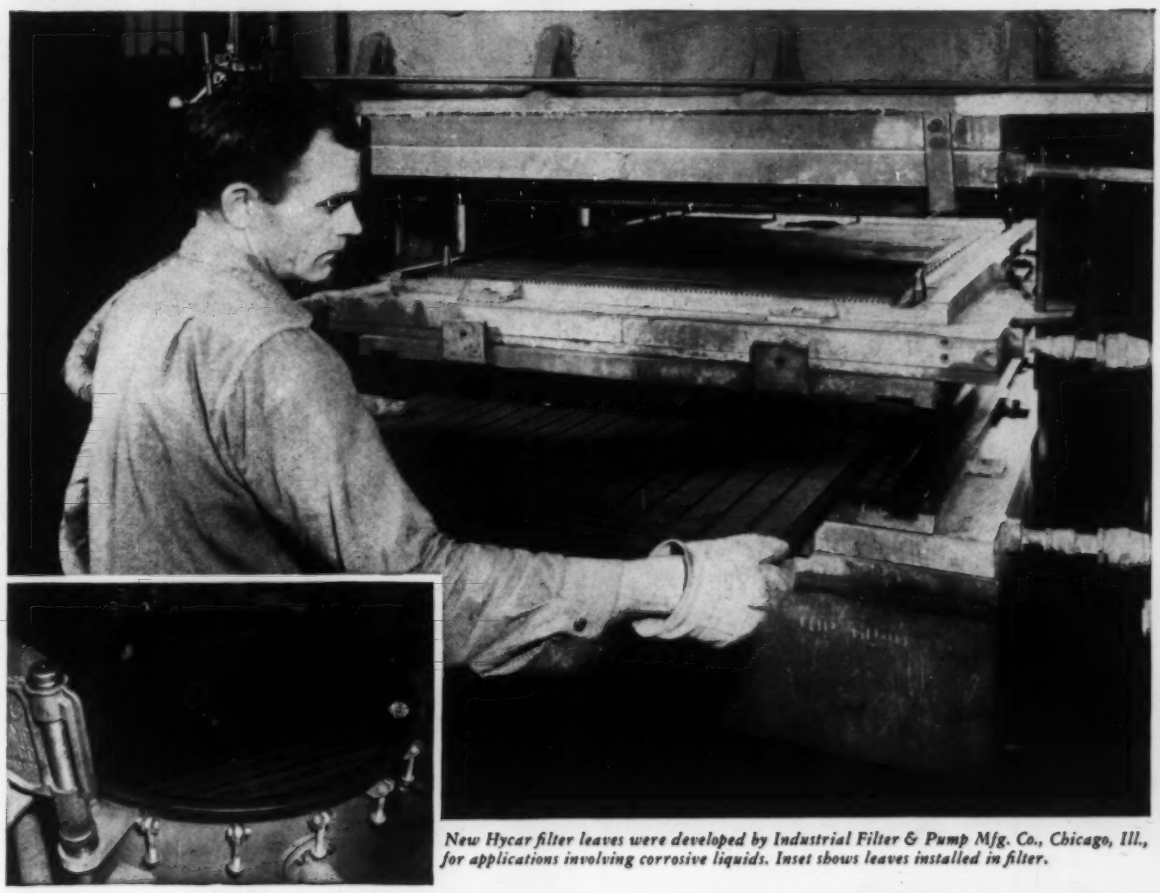
JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND

SINCE 1864 TRADE JENKINS MARK

Another new development using

B.F.Goodrich Chemical *raw materials*



New Hycar filter leaves were developed by Industrial Filter & Pump Mfg. Co., Chicago, Ill., for applications involving corrosive liquids. Inset shows leaves installed in filter.

HYCAR RUBBER TAKES A HOT ACID BATH IN INDUSTRIAL FILTER

FILTERING hot corrosive acids usually means high maintenance and replacement costs. But this filtration equipment is able to stand up to the toughest jobs by using Hycar nitrile rubber as a standard material for molded filter leaf construction.

The Hycar leaves support filtering media such as nylon, cotton, paper, etc., and permit run-off of the filtrate. Hycar provides superior resistance to a wide variety of solvents and chemicals as well as heat—plus excellent aging and abrasion properties. Thus the filter is suitable for processing corrosive chemicals, filtering sugar liquors and other food products, and recovering materials from waste water.

The exceptional qualities of Hycar rubber have led to this kind of product improvement in many industries. It is easily molded and extruded and retains high dimensional stability after shaping. And it can be compounded to provide the right hardness and physical characteristics.

There's probably a need in your own operations for the remarkable properties of Hycar rubber. For complete information, please write Dept. EJ-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, O. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

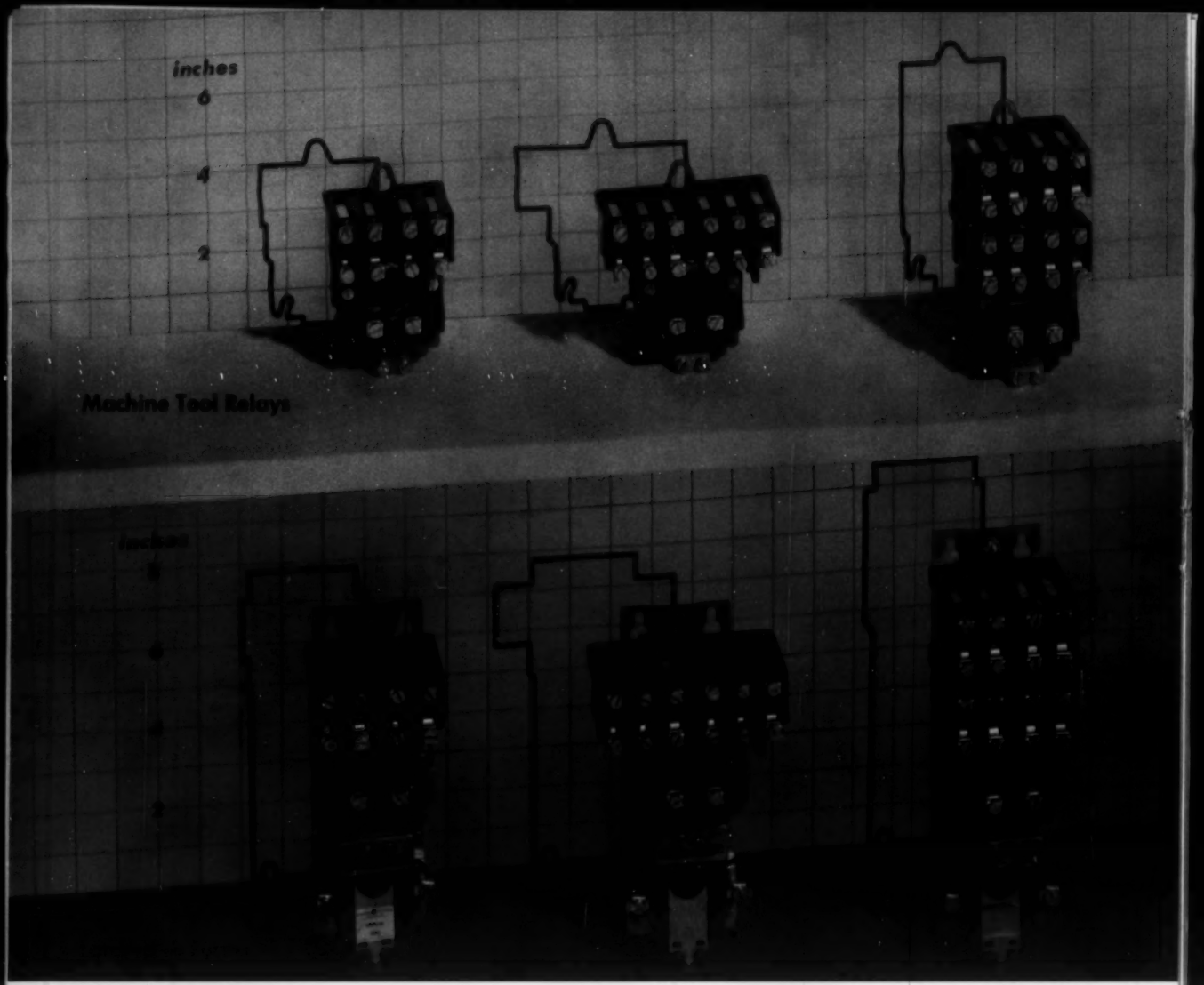
Hycar
American Rubber

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

Circle 427 on page 19

Circle 428 on page 19→



LESS SPACE, MORE FLEXIBILITY, WITH GENERAL ELECTRIC'S–

New Machine Tool and Pneumatic Time-

Machine Tool Relays Require Minimum Mounting Space

General Electric's new relays provide the installation features and long life required by the machine tool industry.

MINIMUM MOUNTING SPACE is required for all the relays—2- through 12-poles. New 6-pole-in-line and 12-pole forms have the same mounting dimensions as the 4- and 8-pole forms respectively.

INSTALLATION and wiring is performed from the front, allowing relays to be mounted close together. The captive clamp-type terminals can be wired from four directions. In addition, contacts can be changed from normally-open to normally-closed without extra parts.

RATING is 10 amps, 600 volts maximum, a-c. Latched-in forms are also available.

Pneumatic Time-Delay Relays Provide High Repetitive Accuracy

The new General Electric pneumatic time-delay relay was designed for applications which require a reliable and accurate time-delay device.

FLEXIBILITY of pneumatic time-delay relay design allows the relays to be supplied with either one or two instantaneous auxiliary contact units, and one or two time-delay contact units. The timing head is available separately for use with Size 0 through 4 contactors and Size 1 through 4 magnetic starters.

HIGH CONTACT RATING of 25 amps "make and carry" at 600 volts maximum means that supplementary relays can often be eliminated. In addition, pneumatic timers can be front mounted and wired for further space savings.

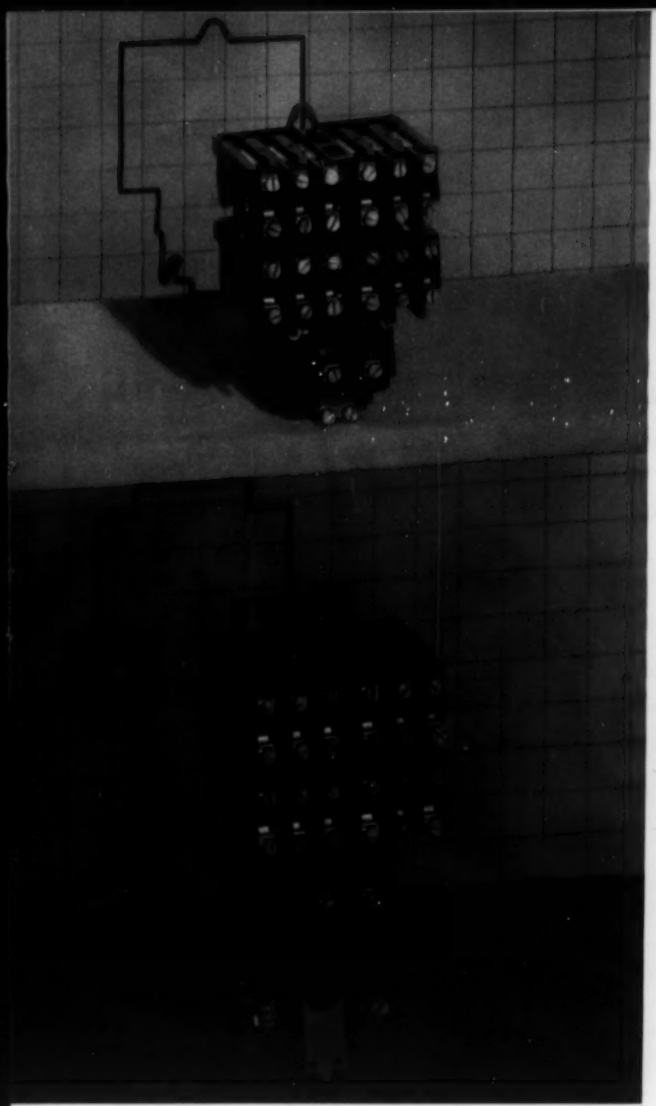
ADJUSTABLE TIME-DELAY permits the timer to be set for any time-delay interval from 0.2 to 180 seconds. Repetitive accuracy is ± 10%, and is not affected by atmospheric conditions. Adjustment is made by a simple screwdriver setting on the front of the unit.

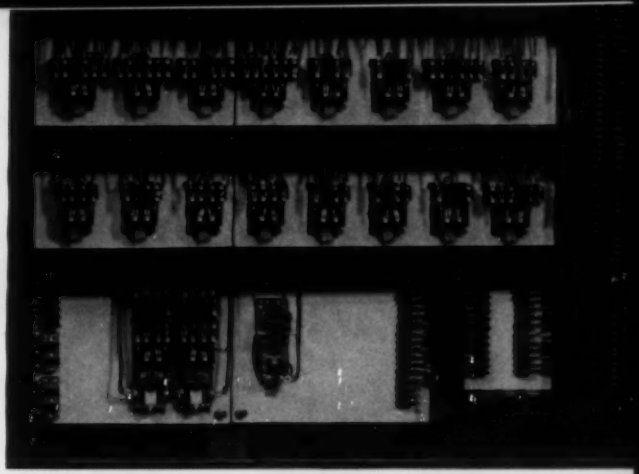
DEPENDABILITY results from many built-in protective features. A special filter mounted in a vertical position in the rear keeps dust and dirt out of the air port. Also, rigid cast construction prevents misalignment.

Relays Used on Pan-A-trol* Panels

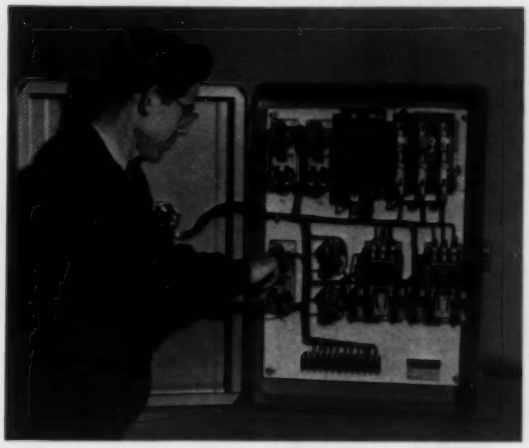
Using machine tool relays, pneumatic time-delay relays, and other standard control devices, G-E engineers build Pan-A-trol packaged control panels to meet your requirements and specifica-

*Trade-mark of General Electric Company





G-E RELAYS permit neat panel mounting arrangement. If desired, relays and wiring troughs may be mounted closer.



PAN-A-TROL PANELS utilize standard components like the new G-E relays, and are factory assembled and wired.

PNEUMATIC TIME-DELAY RELAYS can be modified easily with kits. Also, the timing heads are available separately.

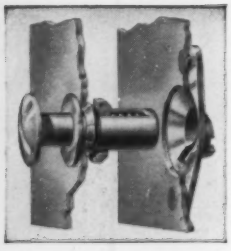
Delay Relays

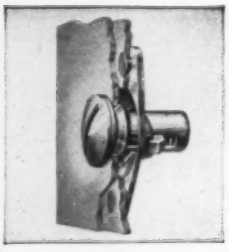
tions. These panels are completely assembled and wired at the factory; only external connections to the machine need be made. Pan-A-trol panels represent another offering by General Electric to simplify the work of design engineers.

Your nearest G-E Apparatus Sales Office can give you complete details on General Electric control devices and on the Pan-A-trol program. If you'd like reference material, write Advertising Section 731-11, General Electric Company, Bloomington, Illinois, and ask for:
GEC-1415 and 1416—Machine Tool Relays
GEC-1425—Pneumatic time-delay Relays
GEA-6334—Pan-A-trol panels

GENERAL ELECTRIC

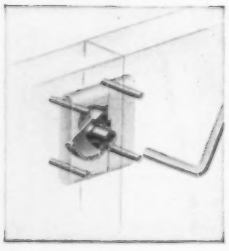
3 ways to save on assembly costs





QUICK-LOCK For fastening removable access doors and panels. Because of its ease of installation, QUICK-LOCK is ideal for assembling removable panels. A 90° turn locks it in place. Stud is self-ejecting when unlocked; visual inspection shows whether fastener is locked. Spring loading takes initial load; solid supports carry increased load. Available in a wide range of sizes.

SPRING-LOCK One-piece fastener for blind holes has load-carrying steel spring wire. Spring steel arms lock fastener securely, prevent loosening under vibration. SPRING-LOCK will work with varying panel thicknesses, locks with a twist of the wrist. Made in all-metal and plastic with steel insert. The molded design permits heads to be made in various shapes for refrigerator shelf supports, washer knobs, brackets. Available in a wide variety of shapes and sizes, and also in custom designs.



ROTO-LOCK Serrated, tapered cam is engaged by formed lug as fastener is locked. Cam action draws panels together tightly, insures locking even under conditions of misalignment. Opens easily for demounting. ROTO-LOCK carries heavy tension and shear loads; can be used for air and water-tight seals: recesses completely into panels. Solidly built without springs or delicate mechanical parts, unaffected by arctic temperatures or field service.

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
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Circle 429 on page 19

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For more facts about stainless steel and the contribution it can make to your product or marketing problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

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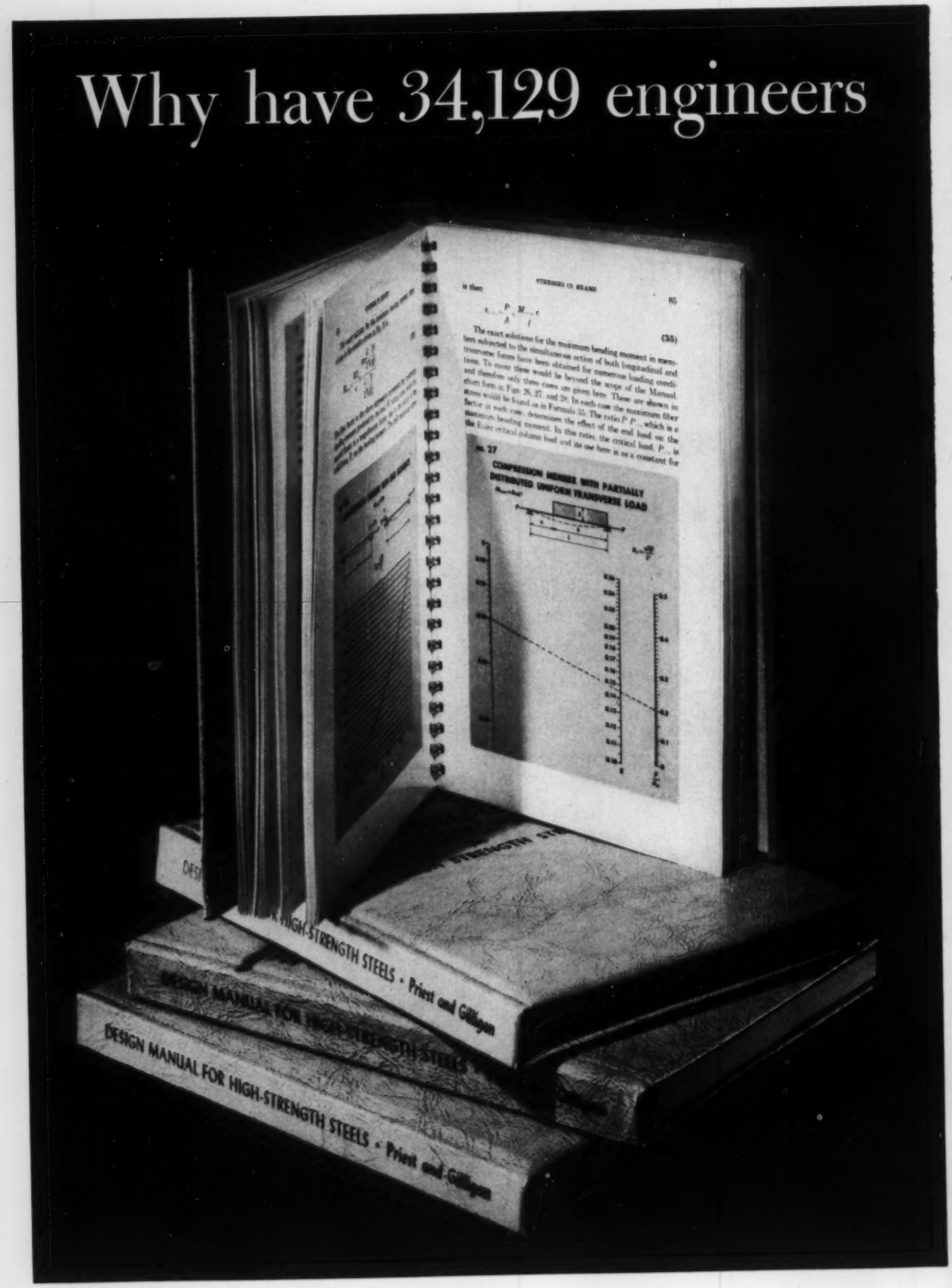
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DESIGN MANUAL FOR HIGH-STRENGTH STEELS • Priest and Gilligan
DESIGN MANUAL FOR HIGH-STRENGTH STEELS • Priest and Gilligan

written us for copies of this unusual book?

Every day we receive an average of 70 requests for our "Design Manual for High Strength Steels." This, despite the fact that in the past two years we have distributed 54,096 of these Manuals—enough to make a stack three times as high as the Empire State Building.

Requests have come not only from design engineers for whose use this book was primarily written, but from men signing themselves as Research Engineer, Project Director, Development Engineer, Design Analyst, Process Engineer, Test Engineer, Mechanical Engineer, Chief Engineer, Methods Engineer, Materials Engineer, Marine Engineer, Industrial Engineer, Electrical Engineer, Aeronautical Engineer, Purchasing Agent, Plant Manager, Chief Inspector, President, and so on and so on. We even had one from a Chairman of the Board. *(Looks like a lot of men besides design engineers are vitally interested in High Strength Steels and want to know how, when, where and why to apply them.)*

While most of these requests have come from all parts of the United States and Canada, an amazing number have reached us from England, Germany, Belgium, France, Italy, South Africa, India, Japan, South America, Australia and New Zealand. *(Seems that no country is so remote that it hasn't heard the good word.)*

What's in this book that makes it such a "must have" for those who have seen it or merely heard about it?

We like to think that the "Design Manual" is finding its place on so many engineers' desks and book shelves—not because it is a costly book, free for the asking—but because it *contains information nowhere else available* and never before presented so clearly and comprehensively.

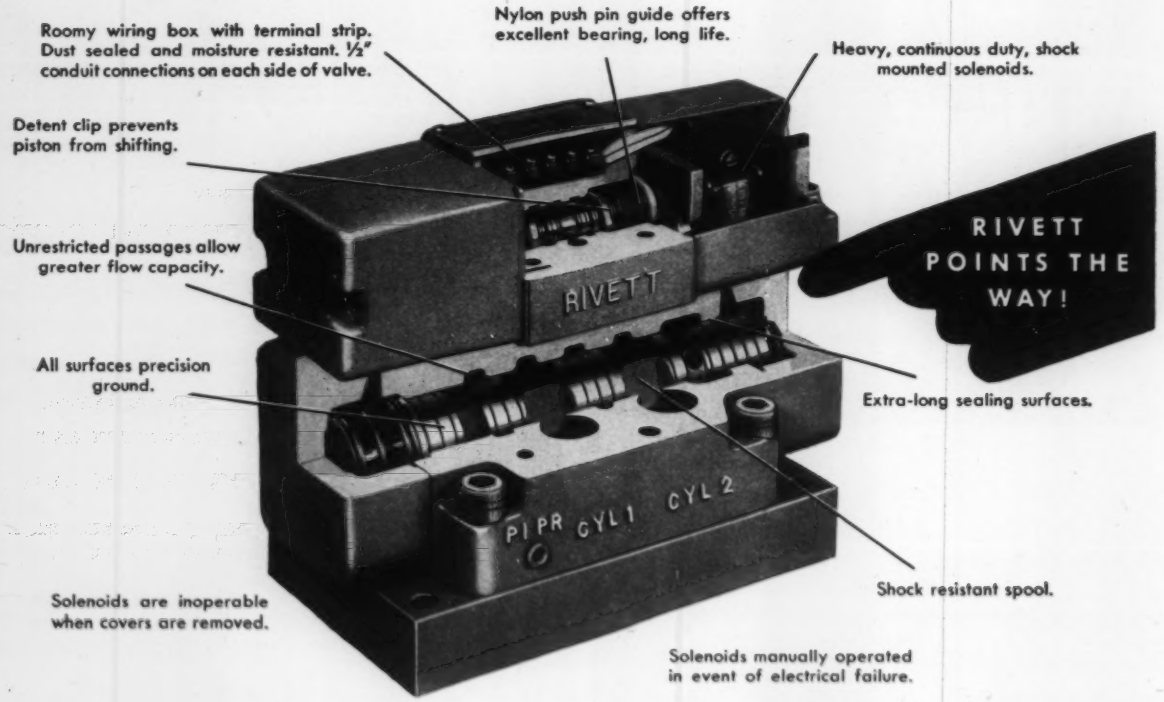
For here, in one volume, the design problems of tension, compression, shear, beam stress, deformation, and deflection are covered in detail, the fundamental characteristics of high-strength low-alloy steels that result in economies to the user are described, the principles of designing against corrosion, and the application and advantages of formed sections are authoritatively discussed.

. . .

Complete with tables, formulas and basic data covering every facet of this important subject, the 174-page "Design Manual for High Strength Steels" is a book that you will find invaluable in designing your product for greater efficiency and economy. A fourth printing is now on the presses. We will gladly send you a free copy if you will write – *on your company letterhead*, giving your title or department—to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS

UNITED STATES STEEL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Design data on adhesives

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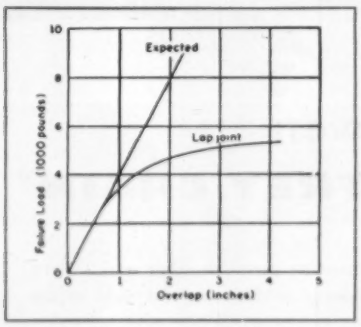
NUMBER SEVEN

How to increase the strength of a lap joint

The shear strength of a metal-to-metal lap joint is directly proportional to the width of the joint. For example, by increasing the width from 1 inch to 2 inches (with depth of lap and gage of metal held constant), the strength is doubled.



Relationship between failure load and overlap.

Strength may also be increased by increasing the depth of overlap. In this case, however, the relationship is not linear. Since the edges of the lap carry a relatively higher proportion of the load than the interior portion does, the *unit* increase in strength gradually lowers as overlap becomes greater.

You can also increase the strength of a lap joint by increasing the thickness of the metal. In fact, unless the metal is of sufficient gage, its yield strength will be lower than the shear strength of the adhesive, even at relatively short overlaps.

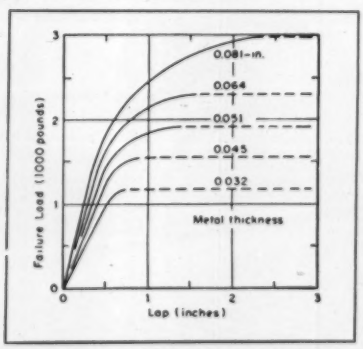


Chart shows interrelation of failure loads, depth of lap and metal thickness for lap joints with a specific adhesive and metal.

Bonding metal to metal

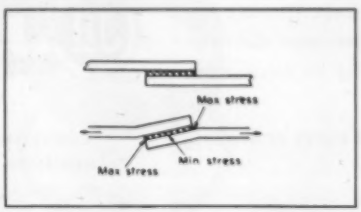
Joint Design

Two of the major factors influencing the design of an adhesive-bonded metal-to-metal joint are the magnitude and direction of the load the joint will have to bear. Most of the adhesives used for bonding metal to metal are relatively rigid, strong in shear, and not so strong in peel or cleavage. Thus, by designing the joint so that the adhesive is in shear, the effect of peel or cleavage stress is minimized.

The most common method of assembling flat metal plates or sheets is through the use of the straight lap shear joint.

Loads Carried by Joint Edges

When a metal-to-metal assembly is in tension, there is a tendency for the edges of the lap to deflect. This is because the stress in each sheet is at a maximum where it enters the joint. (See illustration)



Although the adhesive appears to be in shear, this deflection actually sets up tensile stresses at the edges of the lap, which tend to peel the bond apart. As a result, loads which can cause such an assembly to fail are often substantially below the true strength of the adhesive.

It follows, then, that a high proportion of the load in lap joints is carried by the edges of the lap. This can be illustrated by bonding a 1-inch lap joint with only ¼-inch strips of adhesive on each edge. Such an assembly, bonded with an adhesive with an apparent strength of 3000 psi, will take a 2500 psi load before failure—even with the interior ½-inch of the lap not contributing to the bond. Because the edges bear so much of the load, it is extremely important to get a good bond at these points.

Thickness of Adhesive

The strength of most metal-to-metal joints depends on the thickness of the adhesive film. Although it is commonly believed that the strongest joints are made with the thinnest films, certain types of adhesives show little difference in shear strength over a relatively wide film thickness range—.0005″ to .010″, for example. The optimum film thickness may be different for each adhesive and the manufacturer's recommendation should be followed.

The most effective thickness of adhesive film depends largely on the type of stress the joint must withstand. Difficulties from creep, for example, may be greater with thicker adhesive films. On the other hand, heavier film thicknesses often improve impact and peel resistance, while relatively thin adhesive films can show the highest shear strength.

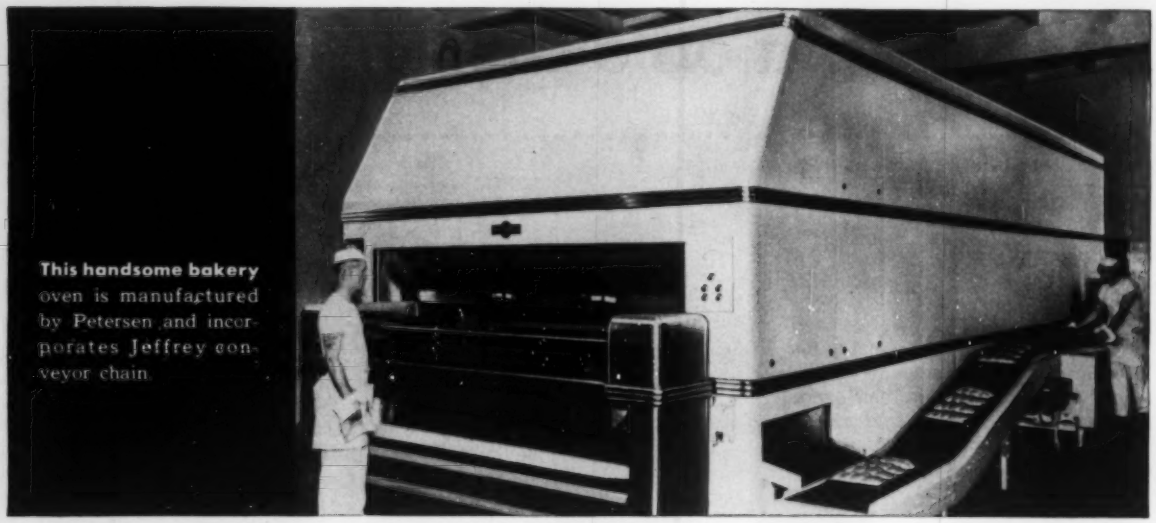
In all cases, the mating surfaces must be free of grooves, slots and waviness, and protuberances or bosses that may interfere with attainment of optimum film thickness.

BONDING METAL TO METAL Here, stiffening members are being bonded to a wall panel on an assembly-line basis.

For more information

Write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, 8002 Dean St., Lancaster, Penna.

Circle 433 on page 19



This handsome bakery oven is manufactured by Petersen and incorporates Jeffrey conveyor chain.

Petersen Oven Co. says,

"Since we mechanized our first oven 28 years ago, we've used **JEFFREY CHAIN**"

The best evidence of the quality of a product is the company it keeps. Jeffrey points with pride to this report on 28 years of close association with Petersen Oven Company of Franklin Park, Illinois.

Jeffrey conveyor chain is employed on Petersen's ovens. It carries bread and cake through the ovens with a care that pleases the most discriminating baker. No tilting or jarring to cause even the richest cake to fall.

Jeffrey makes chain for almost every conveying and power transmission purpose. Our engineers will be pleased to assist in choosing the right chain for your task.

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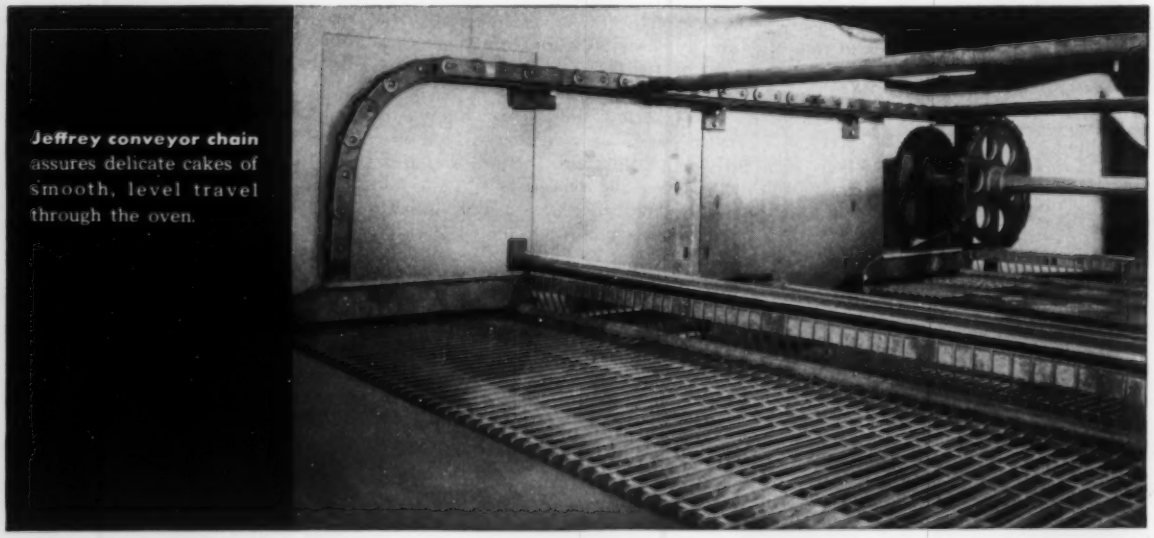
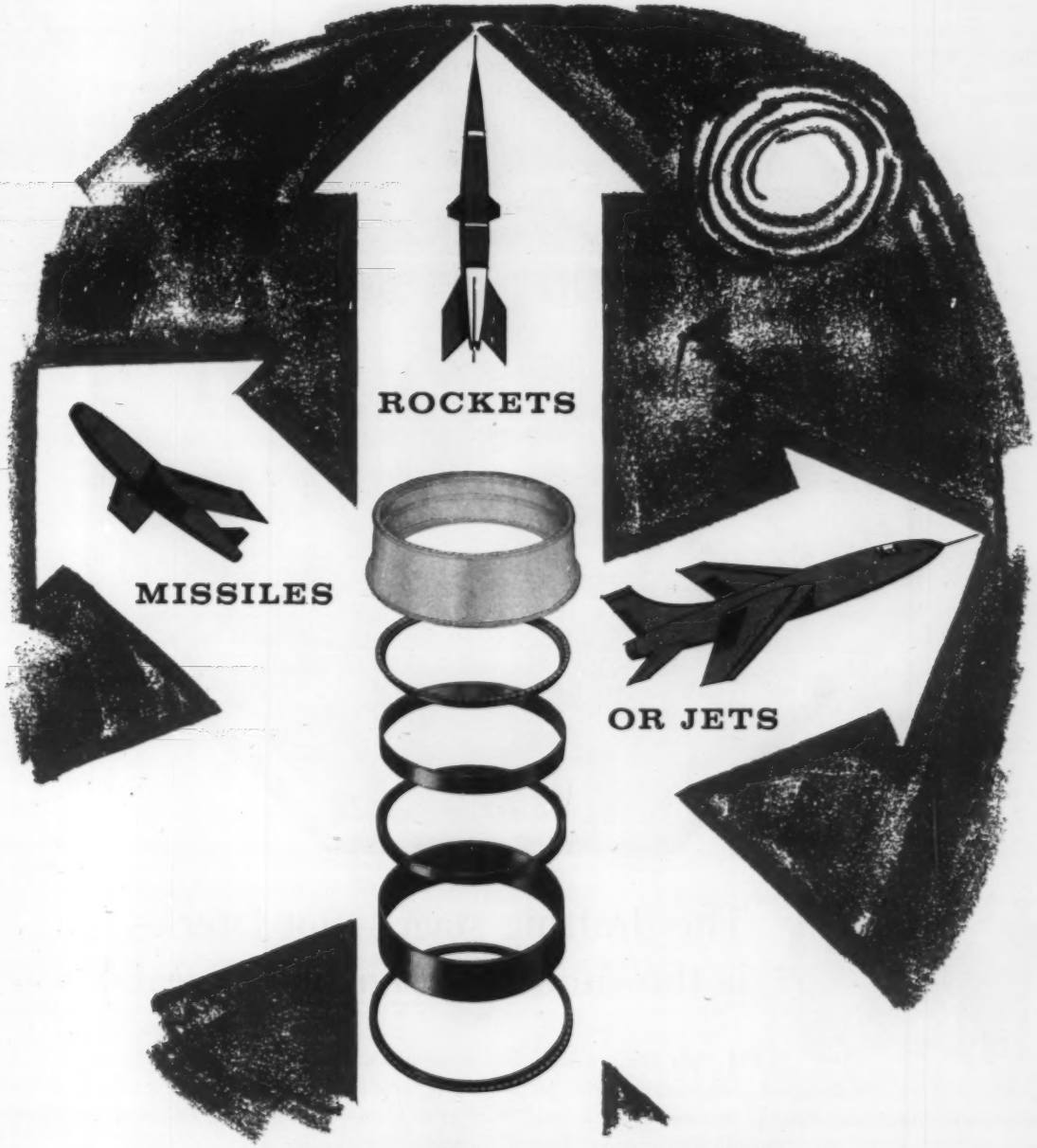


Jeffrey conveyor chain assures delicate cakes of smooth, level travel through the oven.

Circle 434 on page 19



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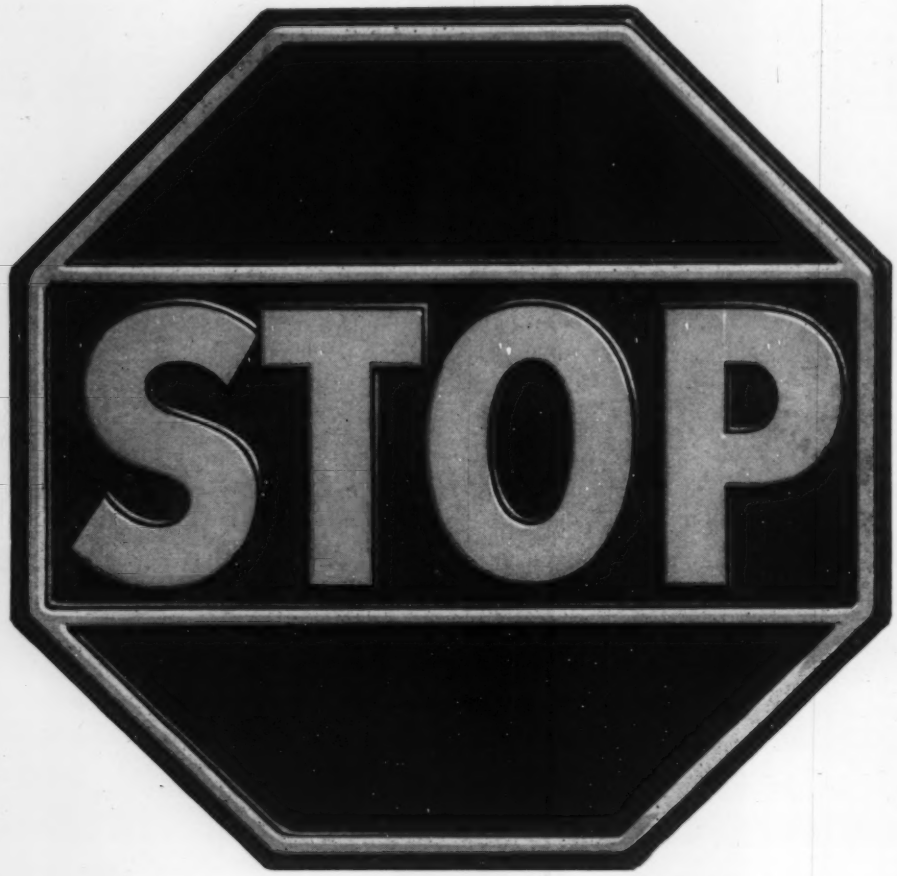

The drafting stage—not later—is the time to design-in oil seals!

Oil seals are precision products. They are designed to operate under a specific set of conditions. Change just one of those conditions—lubricant, shaft speed, temperature, even bearing position—and a different seal will almost always be needed.

Why chance costly retooling or remanufacture? Specify the correct seal on the drawing-board. And when you do, get all the information there is on new seals, new lip compounds, and mechanical designs. Get it from your National Oil Seal Engineer. His counsel is complete, up-to-the-minute, and accurate. You couldn't buy better oil seal information, yet his help is yours for the asking.

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Circle 436 on page 19

(Advertisement)

Vickers Servo Pump Systems

Provide rapid and accurate response to minute electrical or mechanical signals

The Vickers Servo Pump Unit shown at the right is a signal-controlled, variable delivery, positive displacement, reversible flow oil hydraulic pump. In combination with a rotary or linear hydraulic motor, it forms a signal-controlled hydraulic transmission for remote control operations and high-response servo systems.

The servo transmission may be considered as a power amplifier when viewed from the electrical signal input, of about five watts, to the mechanical power output of several thousand watts. Various sizes of transmissions have been built, having output capacity ratings from one to four hundred horsepower. The servo pump develops only that pressure required to move the load . . . which means reduced pressure over the greater part of the system life since peak loads occur only infrequently in the majority of systems. This greatly reduces power losses and minimizes heat rejection.

Any type of prime mover of sufficient capacity can be used to furnish the power input . . . electric motor, auxiliary drive pad on an airplane engine, air turbine, hydraulic motor, etc. Substantially constant speed is desirable.

Variable Pump Volume Controlled by Signal

Heart of the servo pump unit is the Vickers Variable Stroke Hydraulic Pump. This is usually a nine-cylinder pump housed in a pintle-mounted yoke. Varying the yoke angle varies piston stroke, hence, output volume from zero to maximum in either direction of flow. A stroking piston actuated by a pilot valve varies the yoke angle according to signal.

Low Control Power Requirement

Power for control purposes is low in a servo pump unit because metering valve action is confined to the volume-regulating system which is a low power level (100 to 300 psi) hydraulic system separate from the power transmission hydraulic circuit although a part of the pump unit. This volume-regulating system controls piston displacement and direction in the power pump which can operate at pressures up to 3000 or 4000 psi. Pressure drop across ports of a metering valve, with its inherent losses, is avoided in the power transmission system. Final power output from the pump is determined by the volume of flow which the volume-regulating system demands and by the actual resistance of the load . . . is not dependent upon pressure drop methods of control.

In a control system employing this servo pump, the variations in gain resulting from load change are negligible compared to those which may occur in a similar circuit controlled by a valve metering directly in the power line.

Constant Displacement Hydraulic Motor

Flow and pressure generated in the hydraulic pump are carried by tubing with no intermediate valving to the hydraulic motor or linear actuator. The fixed stroke hydraulic motor provides torque directly proportional to pressure and speed directly proportional to flow rate.

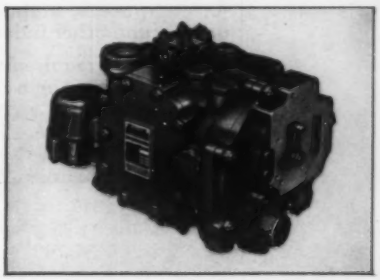
High Power-to-Weight Ratio

The servo pump unit and its associated hydraulic motor are designed for high power-to-weight ratio, high torque-to-inertia ratio, low inertia of rotating parts, and high resonant frequency.

Typical Example

High power-to-weight ratio—3.76 hp/lb (motor only)
High torque²-to-inertia ratio—3.5 x 10^7 lb-in./sec²
Low inertia of rotating parts— .052 lb-in.²
High resonant frequency— 20 cps (entire system)

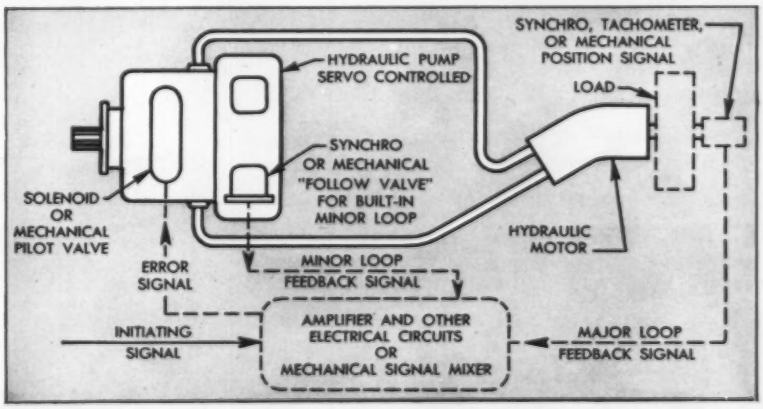
Other advantages are reliability and versatility of application. The smooth,



stepless speed changes and ability to hold position against any variation in load are additional reasons why this unit is a desirable resource which can solve many design problems.

Important among the applications of Vickers Servo Pump Units is extremely fast and accurate positioning of gun turrets on aircraft. Another is actuation of the exhaust nozzle for jet engines; here the servo pump's characteristic of providing at all times only sufficient power to meet the momentary demand minimizes the power loss and therefore the heat rejection. The greatly reduced average pressure level in this type of system prolongs the life and improves the reliability of all components.

For further information, ask for Bulletins SE-15 and SE-18 or get in touch with your nearest Vickers Aircraft Application Engineer. He can arrange for an engineering team to consider your problem and propose an optimum solution.


SYNCHRO, TACHOMETER, OR MECHANICAL POSITION SIGNAL
HYDRAULIC PUMP SERVO CONTROLLED
LOAD
SYNCHRO OR MECHANICAL "FOLLOW VALVE" FOR BUILT-IN MINOR LOOP
SOLENOID OR MECHANICAL PILOT VALVE
HYDRAULIC MOTOR
ERROR SIGNAL
MINOR LOOP FEEDBACK SIGNAL
INITIATING SIGNAL
AMPLIFIER AND OTHER ELECTRICAL CIRCUITS OR MECHANICAL SIGNAL MIXER
MAJOR LOOP FEEDBACK SIGNAL

SIMPLIFIED DIAGRAM illustrates a servo control system employing Vickers Servo Pump Unit and Constant Displacement Hydraulic Motor. This system accepts initiating signals (either electronic or mechanical, depending on type of system), compares them with feedback signals from load and (through controlled changes in direction and volume of fluid pumped to motor) corrects the load as required. For added accuracy and stability, a minor loop providing signals proportional to rate of flow may be added. This may either be built into the pump in the form of a mechanical "follow valve" which results in modulating the flow as a function of the net signal to the pump, or may be a synchro which feeds a signal proportional to flow rate into the amplifier. The controlled output may be either a function of the position or velocity of the load.

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DIVISION OF SPERRY RAND CORPORATION
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Circle 437 on page 19

MICRO SWITCH Precision

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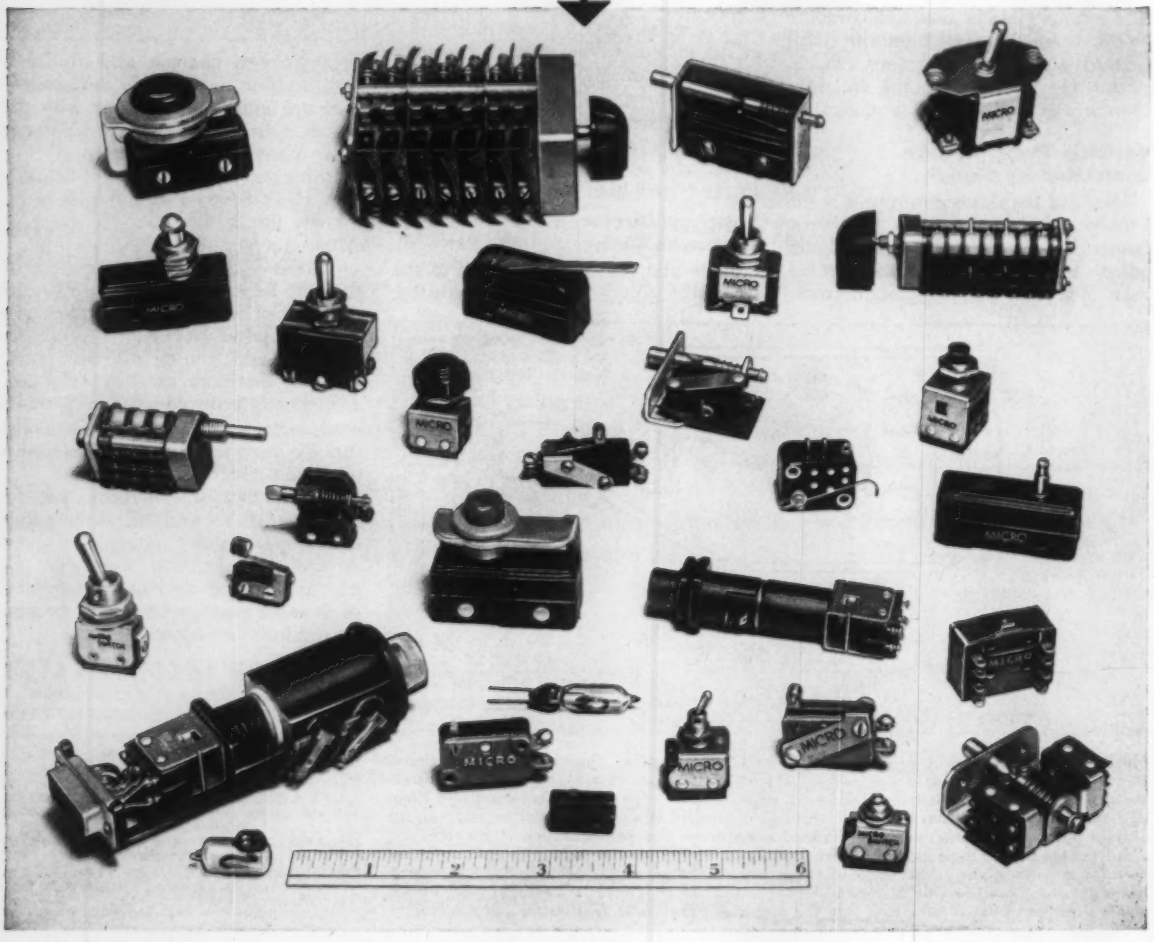
small . . . accurate . . . reliable . . . precise MICRO SWITCH Precision Switches meet wide range of modern electronic control requirements

Design engineers find MICRO SWITCH precision switches to be ideal components for computers, high speed switching devices and other industrial devices.

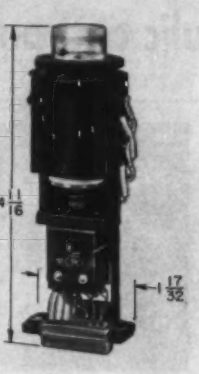
Whether the requirement is for an individual switch—or a complete switch assembly—MICRO SWITCH Engineering is at your service. Development of precise, reliable switching components is our sole business. Our switching specialists have met successfully many knotty problems of switch design and application. This long, practical experience will save YOU time and money.

A call to the nearest MICRO SWITCH branch office will put MICRO SWITCH Field and Factory Engineering to work on your specific problem. This cooperation can be your short cut to improved design.



Switches have uses unlimited

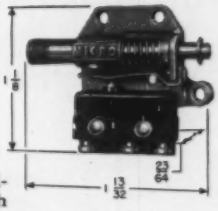
3-LIGHT PUSH BUTTON SWITCH FOR COMPLEX CONTROL PANELS



Here is a new, unique indicating push button switch which lights in three different colors. It is the latest MICRO SWITCH development for use in complex console panels. This compact assembly is ideal for applications where absolute dependability is required. It has a reliable operating life through hundreds of thousands of operations. Use is simplified by a pre-wired connector plug.

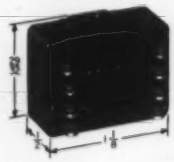
(Send for Data Sheet 110)

SUBMINIATURE SAFETY SWITCH DEVICE FOR HAZARDOUS EQUIPMENT



This MICRO SWITCH Subminiature door interlock switch assembly is designed for use as a safety device on such hazardous equipment as radio, radar, and X-ray cabinets. Installed on the cabinet door the switch automatically cuts off the power circuit when the service door is opened. Assembly shown uses a MICRO SWITCH Subminiature basic switch with single-pole, double-throw contact arrangement.

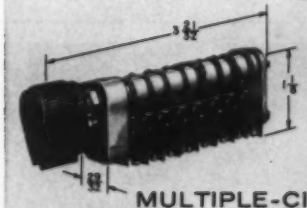
(Write for Data Sheet 108)



FOUR-CIRCUIT SWITCH FOR CONTROL OF COMPLEX CIRCUIT

Here is a four-circuit double-break switch for simultaneous control of four isolated circuits. This small switch is ideal in complex circuit applications where space and weight are prime factors in switch selection. Two snap-action springs are operated with each actuation of the plunger. This provides quick make and break of the contacts in each of the four double-break circuits. Electrical rating is 10 amperes 115-230 volts a-c; 10 amperes 30 volts d-c.

(Write for Catalog 78)

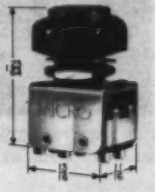


SUBMINIATURE ROTARY SELECTOR SWITCH FOR MULTIPLE-CIRCUIT CONTROL

This assembly is an 8-gang, 8-position rotary selector switch. It consists of 8 single-pole, double-throw Subminiature basic switching units operated by cams on a common shaft. Any combination of the 8 basic switching units may be actuated in any of the 8 positions if cams are set to specifications at the factory. Variations with from 2 to 8 single-pole, double-throw basic switches are available.

(Write for Catalog 75 "Subminiature Switches")

SEALED PUSH BUTTON SWITCH FOR PANEL MOUNTING APPLICATIONS



This MICRO SWITCH push button switch for panel mounting is outstanding because of its very small size and ease of installation. After the push button is mounted on a panel, the switching unit can be wired and then easily snapped into place on the end of the button assembly behind the panel. In addition, the push button is sealed to keep dirt and moisture from penetrating to the back of the panel. Switch has operating force of 3 lbs., weighs but .05 lbs.

(Write for Catalog 75 "Subminiature Switches")

SMALL HONEYWELL MERCURY SWITCH MEETS SMALL LOAD CIRCUIT DEMANDS

The small Honeywell Mercury Switch shown here is especially designed for reliable service in low-energy circuits. This switch meets the requirements of applications where space and economy are critical factors. Mercury switches are widely used in animated displays, control and indicating devices, home freezer units, alarms and hundreds of other tilt-motion, low-force applications. Ratings available down to micro-volt, milli-ampere ranges.

(Write for Catalog 90 on "Mercury Switches")

MICRO SWITCH, a division of Honeywell, is the pioneer in the manufacture of precision snap-action switches.

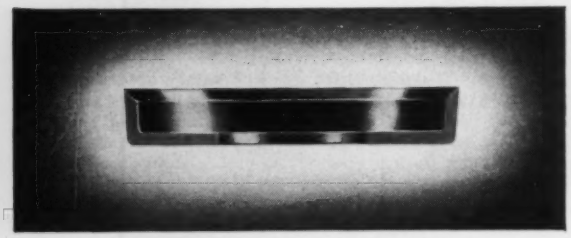
MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

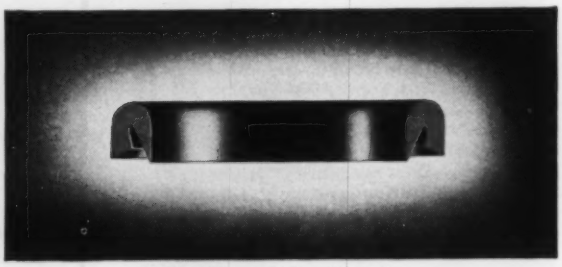
In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Simplify your sealing problems...

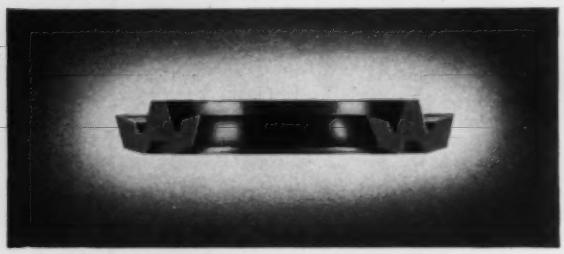
with Johns-Manville Precision moulded packing designs for pressure applications in hydraulic and pneumatic equipment



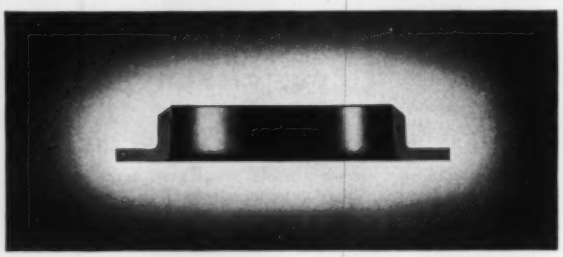
1. Type "A" Packing Cups for pistons
(the original "square heel" cup design)



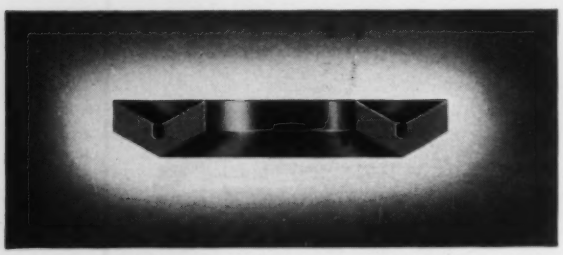
2. Sea Ring packing for rods



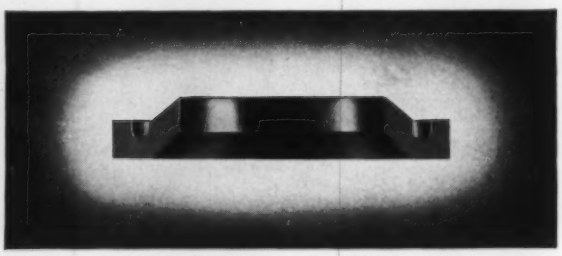
3. Uneepac Packing for rods and pistons



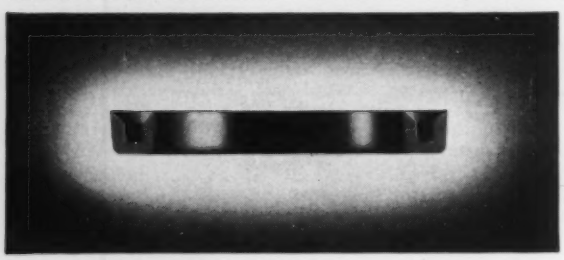
4. Hat Cup Packing for rods



5. V-Rings packing for rods and pistons



6. Cumpac #239 packing for rods



7. U-Cup Packing for rods and pistons

THE WIDE VARIETY of Johns-Manville Packing designs enables you to handle practically any sealing problem. The designs shown on this page are obtainable in a broad range of standard sizes and in materials designed for either usual or special service conditions encountered in hydraulic and pneumatic equipment. Johns-Manville also produces oil seals, moulded gaskets and miscellaneous shapes to specification. See your local J-M distributor or J-M sales office for product or engineering data. Or write Johns-Manville, Box 14, New York 16, N.Y. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville MOULDED PACKINGS

Circle 439 on page 19

Precision-built instrument motor.
Signal corps transmitter blower motor.
Radar voltage regulator gear motor.
Motor parts for portable electric tools.

We Suggest You Consider The Qualifications of This Motor

Representative of the Lamb Electric Motors now in service driving many types of products, this motor:

First, was designed for the particular job to be done, assuring optimum product performance.

Second, was developed and manufactured by personnel having many years of experience in the small motor field.

Third, was *custom manufactured* on a volume basis.

For these and other reasons, use of a Lamb Electric Motor usually results in an improved product . . . *and lower overall costs.* May we demonstrate?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

If you are interested in any of the above motors write and we shall be glad to send full information.

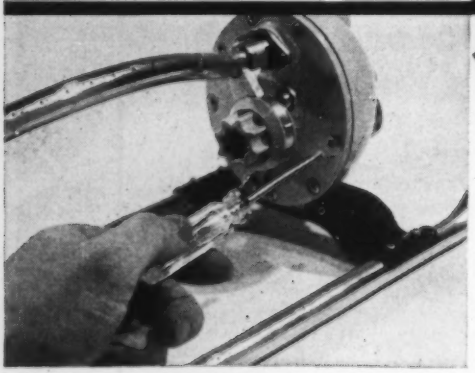
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Investigate the assembly savings made possible by P-K® self-tapping screws

Because P-K Type A Self-tapping Screws have clean, deep slots and sharp gimlet points . . . and because they are consistently uniform, Reznor Mfg. Co. enjoys important savings in the assembly of their gas heaters.

To hold the plastic handle halves of their Instant Heat Soldering Irons together, The Lenk Mfg. Co. specifies P-K Type F Self-tapping Screws. No need for a separate tapping operation. Production is increased and costs reduced—thanks to P-K Screws.



Melnor Industries, Inc. (formerly Melnor Metal Products Co.) puts assembly strength into their famous "Swingin' Spray" oscillating lawn sprinkler by fastening zinc and aluminum parts with P-K Self-tapping Screws—7 Phillips Head Type Z and 18 Type F. They start right . . . drive right . . . and stay tight.

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

PARKER-KALON® fasteners

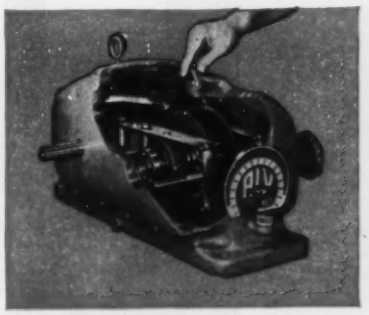
Sold Everywhere Through Leading Industrial Distributors
Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

Because it uses a positive chain rather than frictional elements to transmit power...LINK-BELT P.I.V. delivers

variable speeds with unvarying accuracy

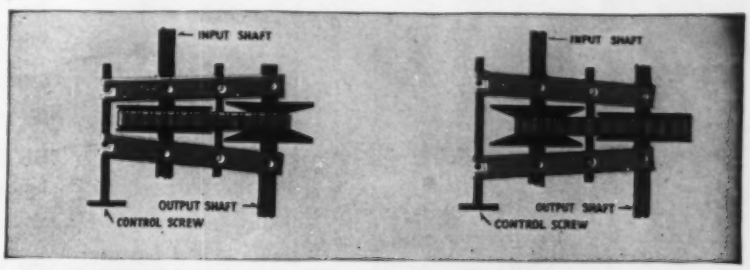
Throughout industry, chain drives have long been preferred as a simple, versatile method of transmitting power positively and accurately. But it was not until the conception of Link-Belt P.I.V. that this advantage was adapted to variable speed drives. With its self-tooth-forming chain principle, P.I.V. provides instant selection of any speed between its maximum and minimum settings without stopping the machine.

TO CHANGE OUTPUT RPM, operator merely turns convenient handwheel to selected speed, indicated by easy-to-read dial.



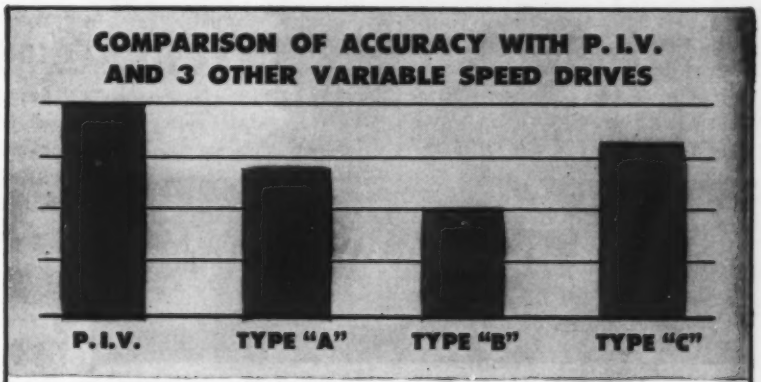
AUTOMATIC ADJUSTMENT of chain tension—by turning hand screw—assures accuracy during long life of drive.

P.I.V. drives are built in capacities from ½ to 25 hp, in 8 sizes and 16 types. Compactness permits installation as a separate unit or built-in part of driven machine.



AT MAXIMUM SPEED SETTING . . . chain grips wheel grooves near perimeter of input side and near center of output side.

AT MINIMUM SPEED SETTING . . . relative position of chain to wheels is reversed, delivering low output shaft rpm.



Using P.I.V. as a standard, bars indicate comparative ability to maintain desired rpm from no-load to full-load relative to three conventional variable speed drives. Chain principle of P.I.V. minimizes speed drop—loss of accuracy which may affect product quality and uniformity. Operating independent of friction, P.I.V. provides instant, positive selection regardless of load or atmospheric conditions.

THE exclusive P.I.V. chain consists of a series of overlapping steel slats. These are free to move transversely from side to side, singly or collectively, serving as teeth. The chain meshes with radially grooved wheels, which are cut at a constant depth toward the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, non-slip contact at any speed, under all loads.

All-metal construction of P.I.V. is unaffected by atmospheric conditions. Housings are of close-grained gray iron—internal moving parts are automatically splash-lubricated.

You'll find much interesting and valuable information concerning P.I.V. in Book 2274 Link-Belt also makes mechanical, hydraulic, electronic and pneumatic controls for regulating these drives automatically, and these are detailed in Book 2349. Ask your Link-Belt office.

LINK-BELT COMPANY: Executive offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.104

Circle 442 on page 19

INSIDE INFO FROM HOLO-KROME

THE SECRET'S IN THE SOCKET!

Since 1932, H-K has completely forged socket screws for greater strength where needed. Originally developed by Holo-Krome, cold-forming maintains metal fibers intact for greater strength. No drilling or broaching to weaken an H-K socket wall. You get tougher screws when they're H-K's!

Holo-Krome sockets completely forged!

Compare These Other H-K Features!

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

SHARP HEX CORNERS . . . carefully formed socket corners resist internal reaming.

UNTAPERED WALLS . . . for better key fit, longer key and socket life, even tighter wrenching.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

HOLO-KROME

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

Circle 443 on page 19

Circle 444 on page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 35

New Pressure Sensitive Tape Has Superior Adhesion at -65 to 500 F

Designers looking for new ways to cut production costs or to improve product performance are certain to find many applications for Permacel EE-3621, a glass-cloth-reinforced tape coated with a pressure sensitive Dow Corning silicone adhesive.

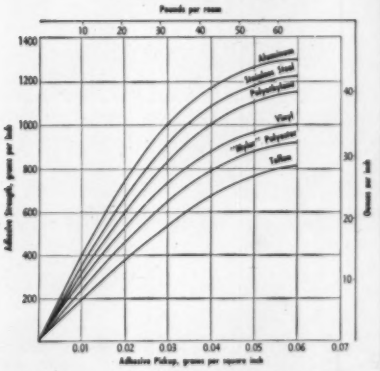
Adhesion values for the new Permacel tape are exceptionally high at extreme temperatures. A 1-inch strip holds—

50 ounces at 150 F
30 ounces at room temperature
74 ounces at —65 F

The tape remains tacky and flexible at —65 F and does not become hard or brittle in service at 500 F. It retains excellent moisture resistance and dielectric strength at all temperatures.

Permacel EE-3621 is supplied with a corrugated glass cloth backing to minimize slippage of wire bundles in the production of electrical components. (Cont. Pg. 2)

TYPICAL ADHESIVE STRENGTH OF EE-3621 ON VARIOUS SURFACES



SILASTIC HELPS MEAT THERMOMETER TAKE GUESSWORK OUT OF ROASTING

Because Silastic* stays rubbery and retains its dielectric properties at temperatures from —130 to 500 F, its use is expanding in many industries. New applications for Dow Corning's silicone rubber range from jet aircraft to this electric meat thermometer developed by King-Seeley Corporation, Ann Arbor, Michigan.

A highly practical tool for professional and amateur cooks alike, King-Seeley's meat thermometer consists basically of a thermistor sealed inside a probe. When inserted into a roast, the thermistor quickly translates meat temperature into electric current which indicates on a dial the degree to which the meat is "done."

Silastic is used to cover the flexible lead wire running to the probe because it remains resilient and retains good dielectric properties despite frequent and sometimes lengthy exposure to 500 F oven temperatures. In addition, since Silastic transmits neither odor nor taste even at these high temperatures, two spring-compressed Silastic washers seal the probe and prevent contamination of the thermistor.

Philco was first to offer the King-Seeley thermometers on kitchen ranges, under the

*T.M. REG. U.S. PAT. OFF. (Cont. Pg. 2)

Silicone Enamel Survives 1000 F In Space Heater Tests

A mishap during a recent high temperature test on space heater finishes dramatically emphasized the superior serviceability of silicone based paints and enamels.

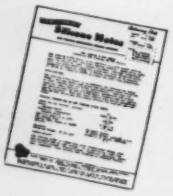
The top surface grill of the space heater being tested was finished with an enamel formulated with a modified Dow Corning silicone resin. "Cooler" areas of the unit—sides and front — were coated with an organic paint.

During the heat test, an oven thermostat failed. Temperatures soared to an estimated 1000 F where they stayed for several hours before the trouble was discovered. By then, the following changes had taken place— (Cont. Pg. 2)

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



All New — 1957 Guide to Dow Corning Silicones is a twelve page, fact-filled catalog which briefly describes the silicone products of interest to most industries. Containing latest data and information, the guide is designed expressly to help you realize the advantages, profits, and savings made possible through imaginative use of these unique engineering materials. *No. 361*

Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists typical applications, and cites factors which contribute to obtaining longer life. *No. 362*

Encapsulating Electrical and Electronic Parts with Silastic, a recently published data sheet, gives details for using two types of Silastic to protect parts against dust, moisture, oxidation, mechanical injury, weathering, and corrosive attack. *No. 363*

Distributors who carry Class H insulating materials in convenient local warehouse stocks, are listed in a revised source of supply sheet. *No. 364*

Engineering brochure on Silastic 50 and 80; includes detailed information on these two general purpose silicone rubbers; provides a convenient reference for design and production engineers. *No. 365*

Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16 mm film allows you to see Dow Corning Silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle ..... *No. 366*

Accuracy Of Timer Assured With Silicone Damping Fluids

Exhibiting remarkably little change in viscosity at temperatures ranging from —70 to over 400 F, silicone fluids have helped engineers design greater dependability into many modern instruments. One interesting new application is found in the "Timelok" manufactured by the Euclid Electric & Manufacturing Company, Madison, Wisconsin.

An integral timing device for controlling d-c motor starters and controllers, Timelok relies on the consistent damping force of Dow Corning 200 Fluid to provide long time accuracy despite temperature variation.

The Timelok timer consists basically of a steel piston inside a hermetically sealed cylinder filled with Dow Corning 200 Fluid. When a coil is energized, magnetic flux pulls the piston through the silicone fluid.

To quote Euclid engineers, "Fraction-of-an-inch movement of a piston within a chamber of silicone fluid constitutes the simplest form of mechanism possible and contributes to the long life of the timer. Silicone fluid offers a distinct advantage over the best petroleum oils because of its very low change in viscosity with varying temperatures. The fluid is also extremely stable and will not break down to form gummy or solid substances."

Timeloks are available in time intervals ranging from 0.2 to 10 seconds, depending on the viscosity of the 200 Fluid employed. Each can be further adjusted manually in a 6 to 1 ratio and all are interchangeable within any contactor.

Euclid designers have always relied exclusively on silicone fluids for dependable damping. They are so confident of the reliable operation of every Timelok that they have a standing offer to replace without cost any timer that fails to outlast the contactor with which it operates. *No. 358*

SPACE HEATER *(continued)*

(1) The organic finish was completely destroyed. All trace of the binder was gone and the dry pigment still adherring to the surface brushed off on contact. The metal under the organic finish had turned blue-black.

(2) In contrast, the grill finished with a silicone resin finish still retained 95% of its original coating. The finish was still well bonded and no noticeable change of color had taken place to mar its original attractiveness.

Comparative tests on special panels later confirmed these findings in the laboratory. After 5 minutes exposure to 800 F, the organic finish had lost all of its binder; after 30 minutes at the same temperature, the silicone finish was still firmly bonded, showed only moderate color change, and still provided maximum protection to the metal underneath. *No. 357*

PRESSURE SENSITIVE TAPE *(continued)*

Although designed for use in Class H motors and transformers, the silicone adhesive permits EE-3621 to be used for many taping applications where extreme temperatures are the order. *No. 359*

MEAT THERMOMETER *(continued)*

trade name "Roastmeter." Hot Point, Magic Chef, and Cribben & Saxton ranges also feature it now. Other manufacturers have either arranged to include the meat thermometer in their line or are considering its early adoption. *No. 360*

Dow Corning Corporation, Dept. 6814, Midland, Michigan

Please send me: 357 358 359 360 361 362 363 364 365 366

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for product design and development engineers by

first in silicones

DOW CORNING CORPORATION

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ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D.C.

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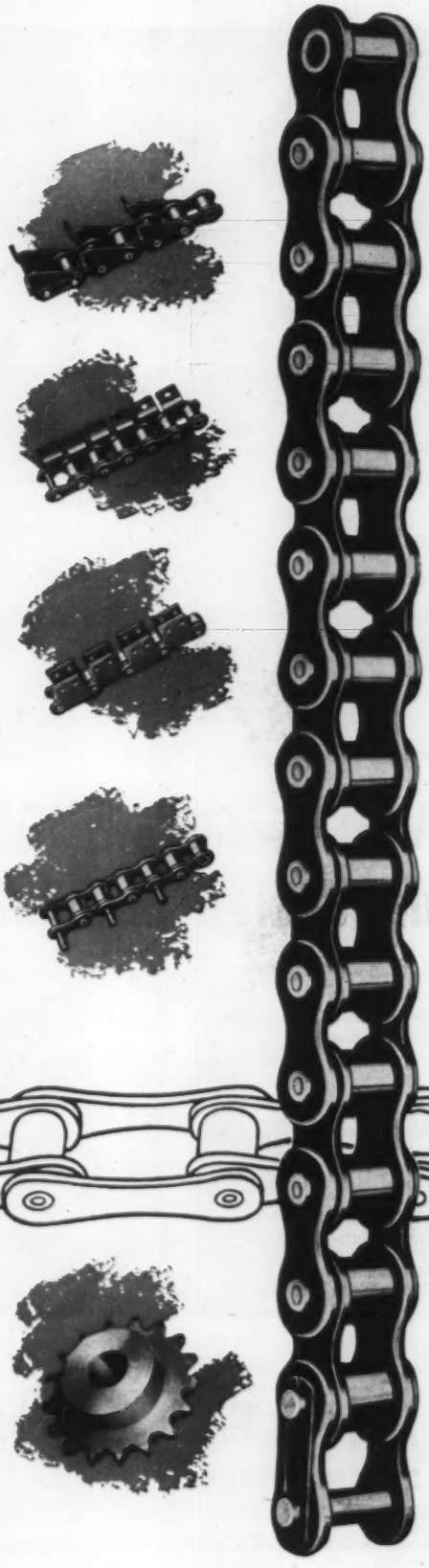
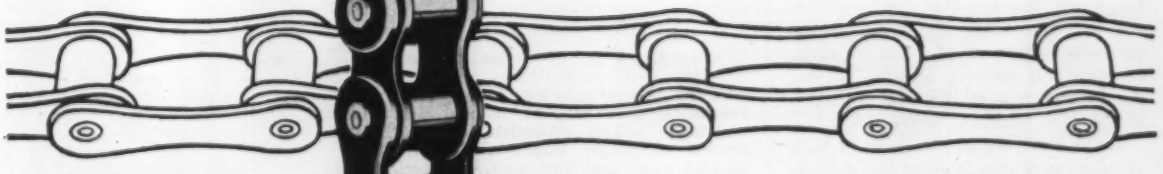


SAVE handling costs

Here's a good way to solve the problem of moving materials, or coordinating actions, on your machine—the complete line of Rex Roller Chains, Sprockets and Standard and Special Attachments. Whether it's moving bread through a wrapping machine...milk cartons through a bottling machine...or metal parts through a plating machine, there is a Rex Roller Chain and Attachment that can do it more efficiently... at lower cost. Your CHAIN Belt District Sales Engineer will be happy to assist you with your selections or to recommend the design of an attachment to suit your individual needs. Call him or mail the coupon today.

CHAIN BELT COMPANY

District Sales Offices in All Principal Cities



CHAIN Belt Company
4643 W. Greenfield Avenue
Milwaukee 1, Wisconsin

☐ Please send me literature on Conveying with Roller Chains.
☐ Have CHAIN Belt man call.

Name.....

Company.....

Address.....

City.....*Zone*.....*State*.....

How R/M FLEXIBLE THIN-WALL Teflon* HOSE can help you solve difficult design problems

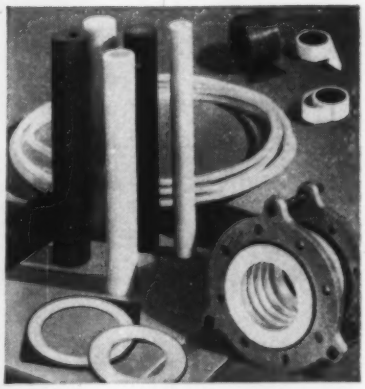
Wherever extreme ambient temperatures and corrosion are problems, your best solution is R/M Flexible Thin-Wall "Teflon" Hose. It can be depended on to retain its flexibility and toughness from −100° to +400°F and it is completely impervious to the corrosive action of all types of acids, caustics and solvents. It does not expand, contract or fatigue. Storable indefinitely without deterioration.

R/M can furnish this hose in both stainless steel wire-braided and rubber-covered forms.

This contribution to better performance and greater safety is the result of R/M's long experience with "Teflon." Ever since it first came into use, our laboratories have been developing the vast potentialities of this material for all phases of industry. Write today for complete information.

R/M's complete line of "Teflon" products includes: rods, sheets, tubes and tape; centerless ground rods held to very close tolerances; stress-relieved molded rods and tubes; gaskets; expansion joints and flexible couplings; Bondable "Teflon"; braided metal and rubber-covered flexible hose; Raylon—R/M trade name for mechanical grade "Teflon"—having many characteristics of virgin "Teflon." Write for complete data.

*A Du Pont trademark



R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION, MANHEIM, PA.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment
Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

Circle 446 on page 19

NEW MINIATURIZED HOWARD MODEL 9200 INDUCTION MOTOR

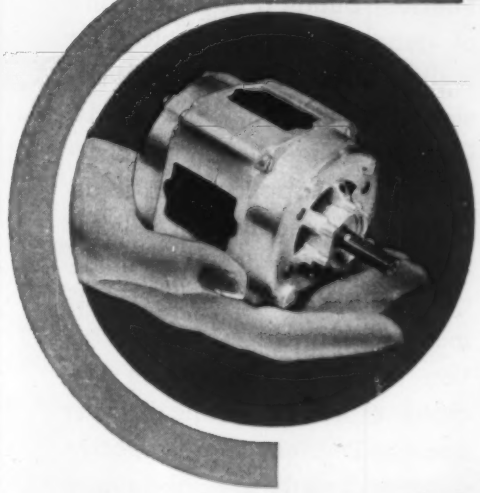
Now available from Howard Industries, Inc. is an exclusive Miniaturized Induction motor with *all* the features of an ultra modern power motor for use in tape recorders, communication equipment, office machines, turn table, movie projectors, air craft, instruments, electronic devices and many more applications.

Special design of magnetic and electrical circuits (24/20 slots), sinusoidally distributed windings, internal rotor slotting combined with unique mechanical features result in exceptionally quiet operation, low level magnetic hum, reduced external magnetic field, low temperature rise, minimum cogging and hunting.

Howard's Model 9200 has been rated by experienced engineers as the finest small induction motor on the market.

Performance ratings of these motors are outstanding, comparable to those of considerably larger frame sizes. For complete details, engineering drawings and samples, write, wire or phone HOWARD today.

unusual power in a small frame size



HOWARD MODEL 9200 Permanent Split Capacitor, Single Phase, 50/60 Cycle Induction, Torque, Synchronous Type—Also available in two or three phase designs.

PERFORMANCE COMPARISON TO CONVENTIONAL MOTOR OF THE SAME OUTPUT RATING

reluctance synchronous single phase permanent capacitor type

	Good Reluctance Motor	Howard SWC-9214 Motor
HP	1/75	1/75
Volt	115	115
C.P.S.	60	60
R.P.M.	1800	1800
Capacitor	2.5 MFD	2.5 MFD
Load Torque	7.5 oz. in.	7.5 oz. in.
Line Amps (input)	.37	.33
Line Watt (input)	36	34
Power Factor	85%	90%
Efficiency	27.7%	29.5%
Temperature Rise °C	36.5°C	26.3°C
Starting Torque	10 oz. in.	11 oz. in.
Pull-in Torque	9 oz. in.	11 oz. in.
Pull-out Torque	9.5 oz. in.	12 oz. in.

CONSTRUCTION SPECIFICATIONS:

General: Open, self ventilated, versatile mount construction. Laminations are stamped from high grade silicon electrical steel. The stator core is housed inside a rigid framework consisting of the two aluminum die cast end brackets telescoped into each other with both rabbets precision machined from bearing bores.

This type of construction eliminates the danger of bending out of shape of the stator structure which is possible in a conventional skeleton type motor.

Bearings: Motors can be supplied with porous bronze sleeve bearings of self aligning or rigid type. An adjustable thrust and end play device is provided with each motor for horizontal, vertical, or thrust loading. With sleeve bearings, large felt oil reservoirs are provided. At request, motors can be supplied with permanently lubricated sealed or shielded ball bearings.

Mountings: Motor frame is designed to permit 6 types of mountings:

Rigid pad or base	Flange mounting
Recessed pad	Extended nut or thru bolt
Resilient ring (small and large size)	Face mounting

Frame Size: 2⅛ x 2⅛ with overall length of 4 1/32 for 9210 frame and 4 13/32 for 9214 frame.

Ratings: Single phase, 115, 50/60 cycle, permanent split capacitor, continuous duty, 40° C. rise and 2 & 3 phase 230 volts, 50 to 60 cycles.

Induction Type:	(RWH 9210 & 9214) 2, 4, 6, & 8 Poles HP Range: 1/300 to 1/30 Hp
Torque Motors:	(RWC 9210 & 0214) 4 & 6 Pole Torque Range: 5 to 12 Inch-Ounce of Stalled Torque Cogging of 6 pole motor + or −2%
Reluctance Synchronous:	(SWC 9210 & 9214) 2 & 4 Pole HP Range 1/250 to 1/50 HP
Hysteresis Synchronous:	(HWC 9210 & 9214) 2, 4, 6, & 8 Pole HP Range: 1/250 to 1/75 HP

HOWARD MOTORS: *Universal & D.C.—1/200 to 1/2 HP, Shaded Pole—1/2000 to 1/8 HP, Induction—1/1400 to 1/4 HP, Servo Motors · Gear Motors · Blowers*

HOWARD

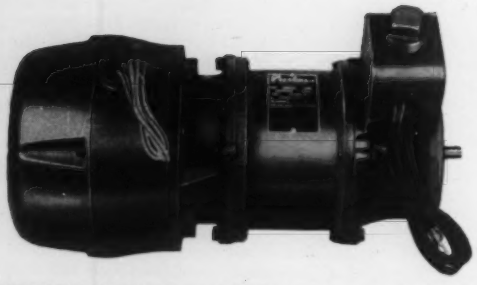
HOWARD INDUSTRIES, INC. 1735 State St., Racine, Wisconsin/Teletype: RAC 344

Sales Offices: - 208 S. La Salle St., Chicago 4 · 942 S. La Brea Ave., Los Angeles 36 · Room 4822, Empire State Bldg., New York 1

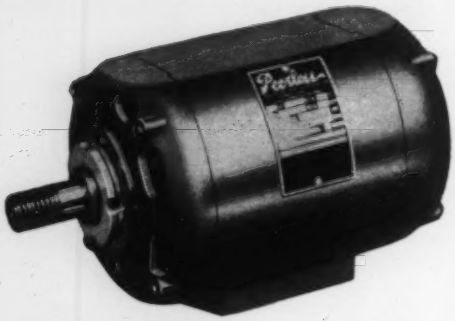
Buy Defense Bonds

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

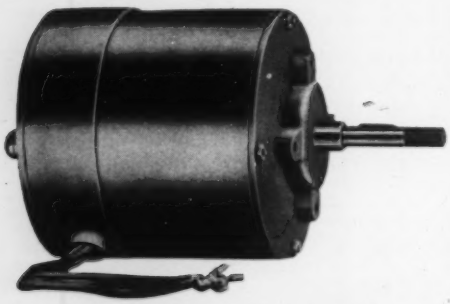
Circle 447 on page 19



EXPLOSION-PROOF TORQUE MOTOR WITH BRAKE



COMPACT DESIGN RADIAL SAW MOTOR



NAVY MOTOR—SPRAY-TIGHT

SPECIAL MOUNTED VERTICAL MOTOR

If stock motors cut machine efficiency see Peerless.

Peerless builds a complete line of general purpose motors as well as hundreds of specials designed to meet specific needs. Our engineers have wide experience in applications of all types, and specialize in solving motor problems for design engineers who require unusual mountings or unusual construction to achieve maximum machine efficiency. Consult your nearby Peerless representative or write directly to us about any motor problem. We'll work with you to develop the one motor that powers your equipment best. Write for Bulletin SDA-155 now.

Single phase
½ thru 7½ HP

Polyphase
½ thru 30 HP

ELECTRIC MOTOR DIVISION
THE *Peerless-Electric*® COMPANY
FANS • BLOWERS • MOTORS • ELECTRONIC EQUIPMENT
1520 W. MARKET ST • WARREN, OHIO

Circle 448 on page 19

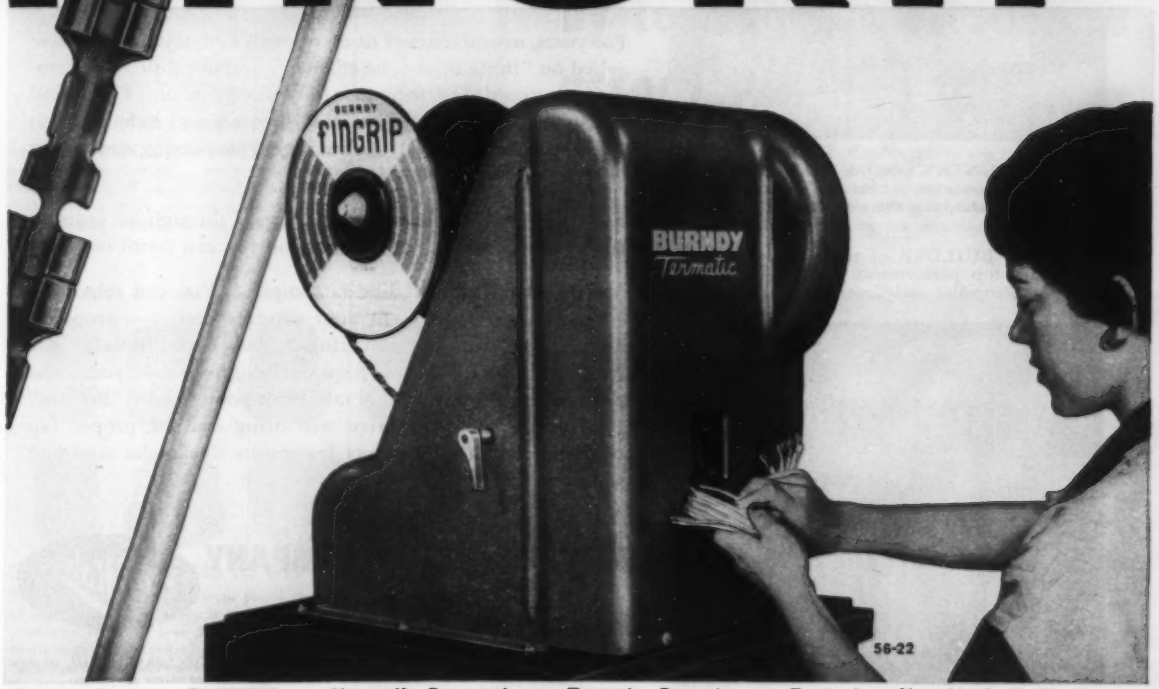
from this to this... in 3/5 of a second!*

Two elements—the rugged, inexpensive FINGRIP, and the fully automatic, easily-loaded TERMATIC—form the new Burndy FINGRIP METHOD, permitting a speed and ease of uniform electrical termination never before possible. NO PEDALS OR LEVERS TO PRESS, and no pre-positioning of wire necessary—insertion of the wire end actuates the TERMATIC, virtually eliminating rejects and minimizing operator fatigue. The machine is quickly and easily loaded (less than 15 seconds) and is completely enclosed for operator's protection. The FINGRIP, an inexpensive, quick-disconnect terminal, has FOUR individual pressure elements—permitting greater flexibility and abuse without damage. Write Omaton Division, BURNDY, Norwalk, Connect. for general information or for solutions to specific terminal problems. Our engineers are always available for personal consultation.

*6000 per hour by actual customer test.

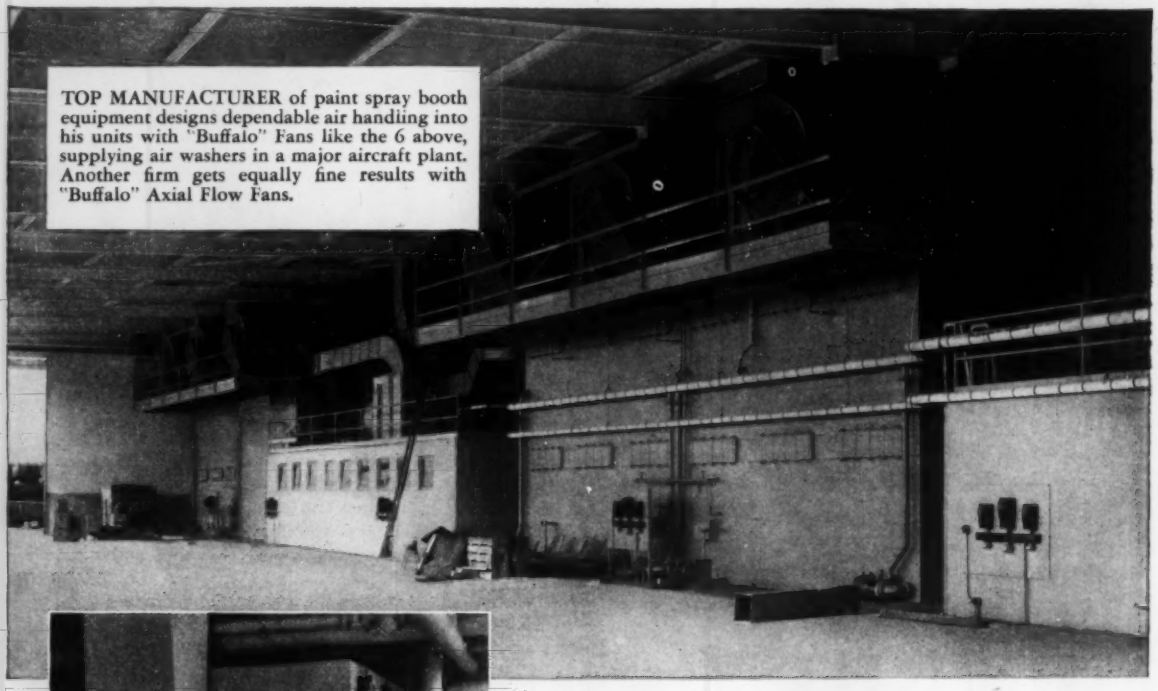
BURNDY

FINGRIP

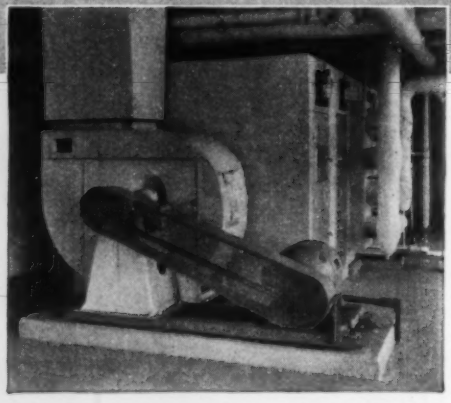


Omaton Division, BURNDY • Norwalk, Connect. • Toronto, Canada • Factories: New York, Calif., Toronto

IF THERE'S A FAN IN YOUR PRODUCT

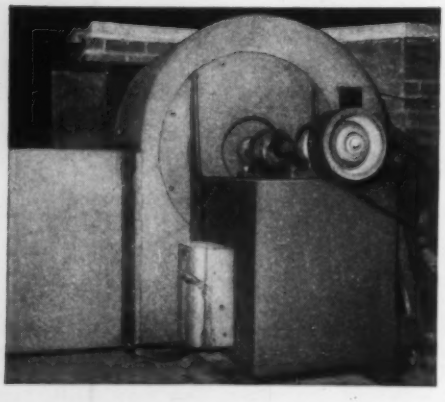


TOP MANUFACTURER of paint spray booth equipment designs dependable air handling into his units with "Buffalo" Fans like the 6 above, supplying air washers in a major aircraft plant. Another firm gets equally fine results with "Buffalo" Axial Flow Fans.



IN THE COUNTRY'S NO. 1 AIR CONDITIONING installations, you'll often find "Buffalo" Type "BL" Fans distributing the air.

LEADING BUILDER of tunnel kilns insures continuous top performance and long life with "Buffalo" Propeller and Centrifugal Fans.



MAKE IT "BUFFALO" FOR BEST RESULTS

For years, manufacturers of equipment embodying fans have relied on "Buffalo" for the efficiency and durability so necessary to successful performance of their equipment. You'll find everything from small "Buffalo" Blowers and Exhausters to high-capacity Type "BL" Centrifugal Fans serving equipment everywhere and serving it well.

First, "Buffalo" fanmanship, developed through 80 years in the business, means fan construction you can count on.

Second, the "Buffalo" line is complete. You can select the exact type and size to fit your product design — propeller fans, axial flow fans, centrifugal fans. And "Buffalo" has facilities to supply you with special designs to meet your most particular requirements. A talk with your nearby "Buffalo" Engineering Representative will bring out the proper fan to design into your product for results that make sales and reputation for you.

BUFFALO FORGE COMPANY

BUFFALO, N. Y.

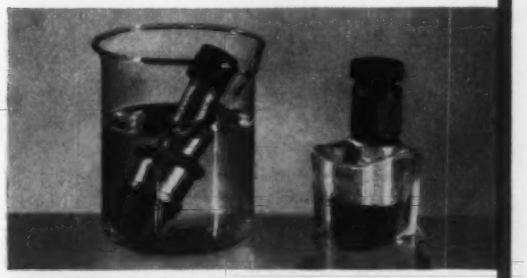
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo"

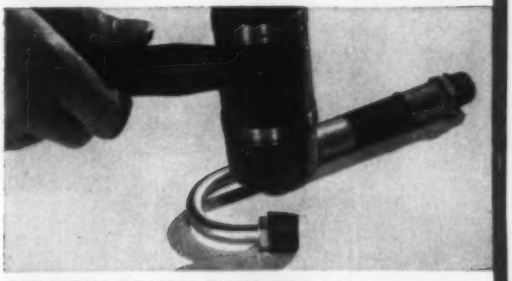
VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING
FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 450 on page 19

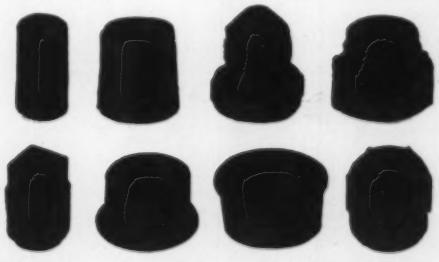
SEE HOW EASY THEY SLIP ON, AND OFF! Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Threaded styles are knurled to spin on or off with ease. Costing less to buy, they cost less to apply.



SEE HOW THEY WITHSTAND ACIDS, SOLVENTS, HEAT AND COLD... and keep out dust and moisture, too. Dunk a CaPlugged product in any solution. Subject it to actual process conditions and temperatures. Made of tough, flexible Polyethylene, CaPlugs are impervious to most common chemical reagents, acids and solvents ...retain form stability under stress at temperatures from –94°F. up to 175°F.



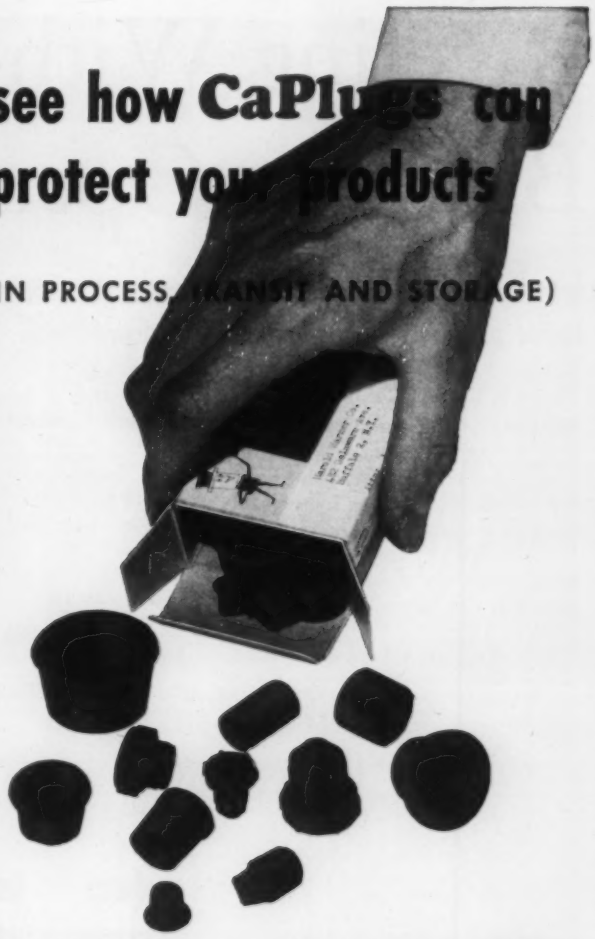
SEE HOW TOUGH THEY ARE. For proof, drop a product on its CaPlug...tap it with a mallet...or make a trial shipment of parts with CaPlugs applied. You'll find that these versatile closures provide "kid-glove" protection and will not collapse, chip, break or shred under the most severe of conditions.



SEE HOW EASY IT IS TO GET CaPlugs THAT FIT. By mailing the coupon, you'll receive a free sample of each of the ten different styles which are available in a combined total of over 300 stock sizes. There's a CaPlug that's *right* for practically any closure need. You name it! "Off-the-shelf" deliveries from a 30,000,000 inventory can be made to answer immediate requirements promptly.

see how CaPlugs can protect your products

(IN PROCESS, TRANSIT AND STORAGE)



by testing a free sample assortment like this

YOU'RE INVITED TO TEST CaPlugs in any way you choose. The coupon below will bring a random assortment to your desk...plus illustrated literature, complete details and prices. Reasonable quantities of additional samples in specific sizes for testing are also yours for the asking (details in literature).

MAIL THIS COUPON FOR FREE BOX OF CAPLUGS, DETAILS AND PRICES

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2201 Elmwood Ave., Buffalo 23, N. Y.

RUSH a free assortment of CaPlugs, literature and prices to us, without obligation.

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Riveting With a Hammer in Blind or Open Applications

Elimination of special riveting tools can mean faster production, lower costs, no down time.

J. K. BARRY, M. E.

The use of blind rivets installed with only an ordinary hammer from one side of the job offers a highly simplified method of fastening. Speed, convenience and *low installed cost* make Drive Riveting preferable not only for blind joints, but for fastening many parts that can be reached from either side.

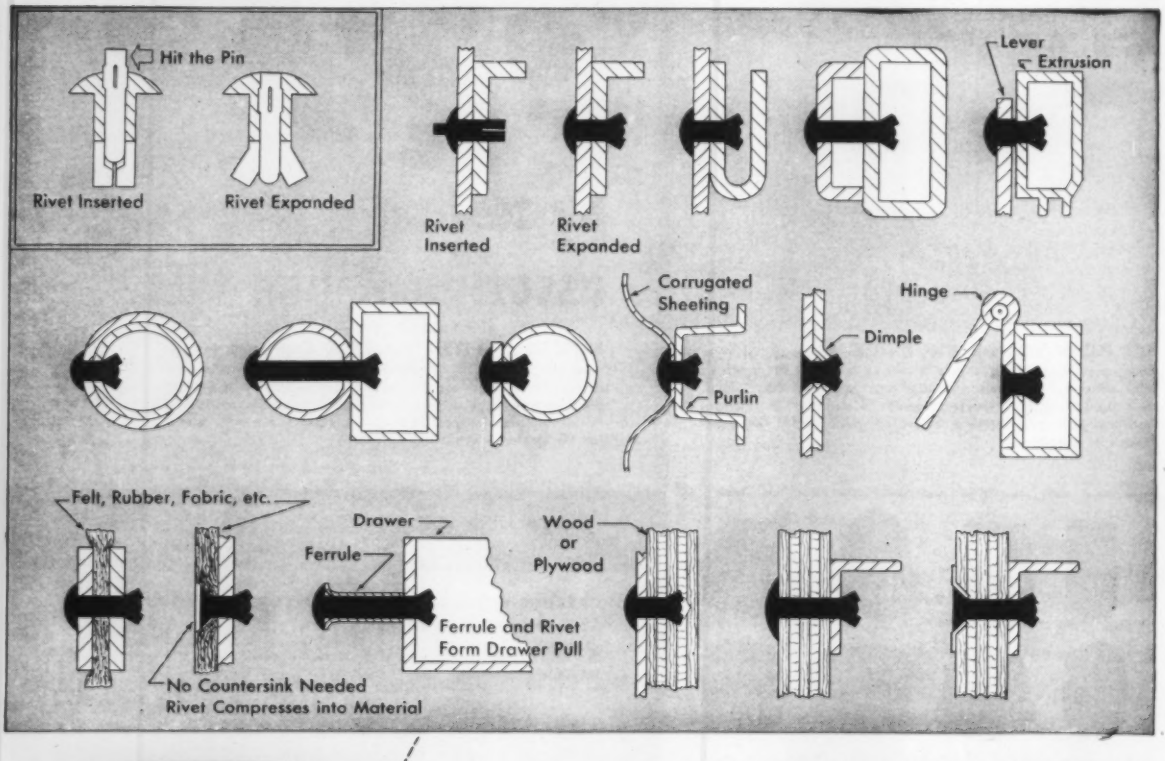
The Southco Drive Rivet has a cored, slotted body with a grooved pin protruding from its head. When the rivet is inserted through parts to be fastened, the pin is driven flush with the rivet head causing the expanding prongs to form a blind head behind the rear sheet. No further finishing is necessary, since the pin seats itself permanently to complete the smooth head contour.

Drive Riveting has five major advantages:

1. No investment in special tooling.
2. No lost time for tool repairs.
3. No limitation on the number of men who can install rivets.
4. Speed comparable to nailing.
5. Only one man is needed.

Widely used in truck bodies, storm doors, metal buildings and hundreds of other industrial applications, Southco Drive Rivets make a secure, vibration resistant joint. A wide range of head styles, diameters and grip lengths is available.

RECOMMENDED APPLICATIONS FOR DRIVE RIVETING



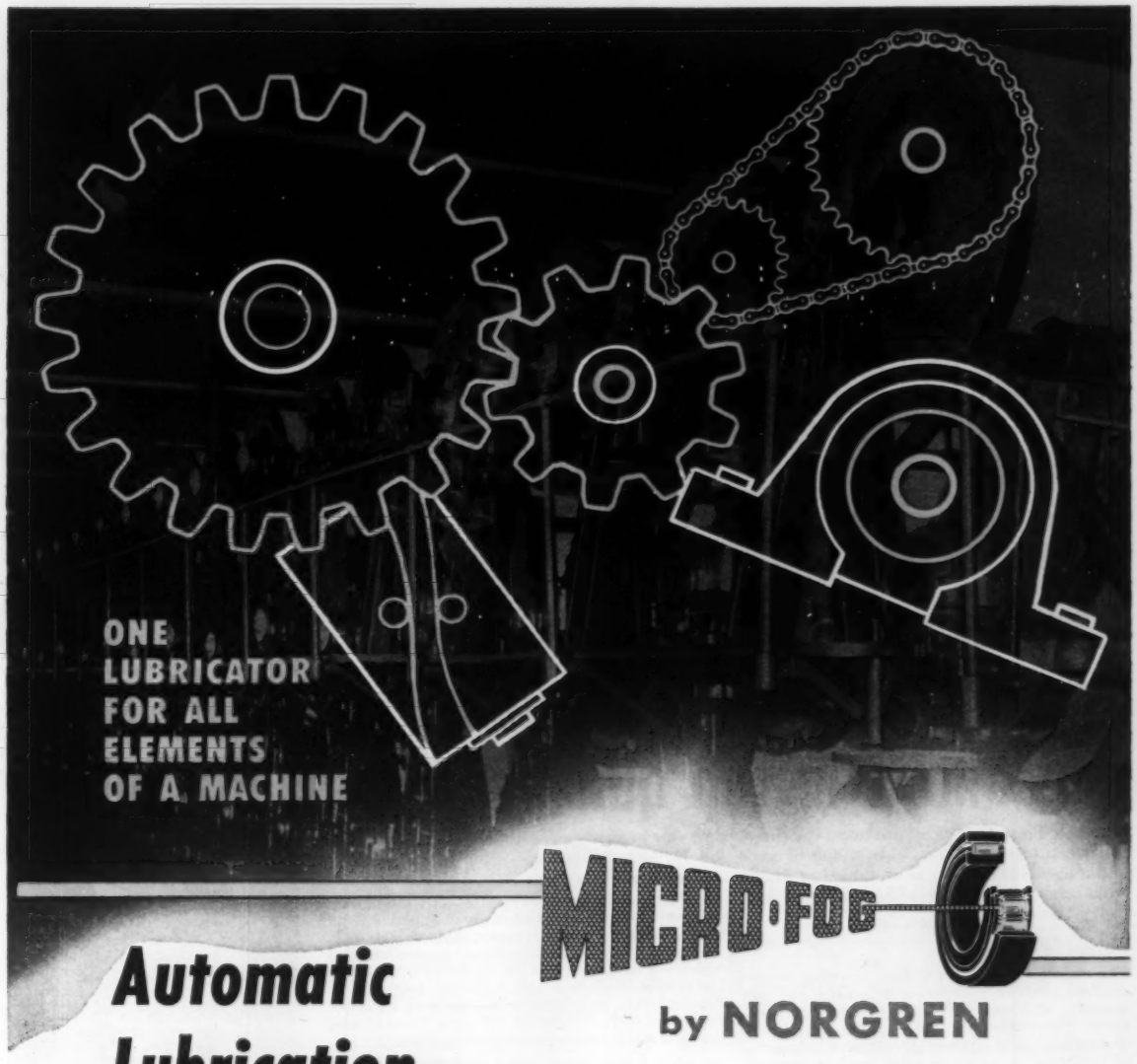
SOUTHCO FASTENERS

©1956

LION

Southco Div., South Chester Corporation

237 Industrial Highway, Lester, Pa.



Automatic Lubrication

by NORGREN

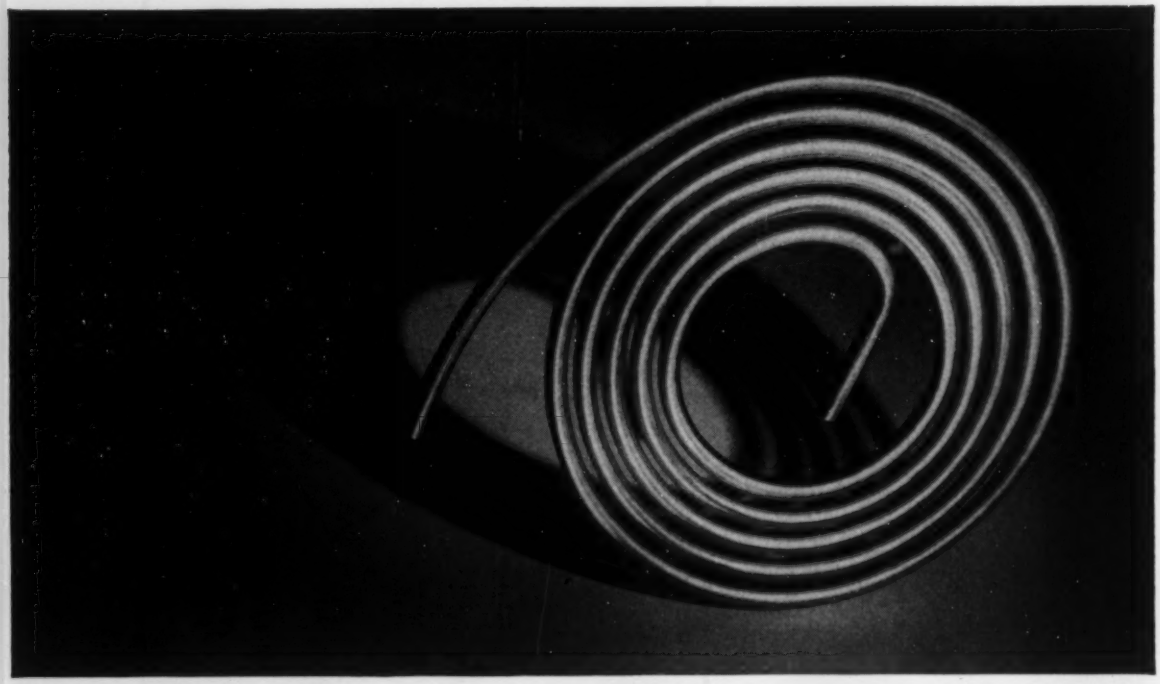
ONLY ONE Norgren MICRO-FOG Lubricator is required to completely lubricate a complex machine. It automatically and continuously applies a protective film of fresh oil to each bearing, gear, chain or cam. Just the right amount of oil, no more, no less, provides the most efficient lubrication, holding machine wear to a minimum.

To learn how MICRO-FOG Lubrication can cut costs in your plant, call your nearby Norgren Representative listed in telephone directory, or *Write Factory for New Catalog.*

C. A. NORGREN CO.

3442 SO. ELATI STREET ENGLEWOOD, COLORADO

Circle 453 on page 19



Superior offers the widest range of sizes and alloys in top quality instrument tubing

Superior Tube Company produces the finest instrument tubing in a wide range of sizes and alloys—offers you as standard products what many makers would classify as specialty tubing.

1. NEEDLE TUBING

The stainless steel links in this recording instrument are made of Superior needle tubing. The high strength, stiffness, and strict dimensional tolerances characterizing this tubing—originally designed for surgical uses—have opened new fields of industrial applications when used as mechanical tubing.

2. PRESSURE AND SUPER PRESSURE TUBING

A spiral windpipe made of Superior 304 cold-drawn seamless stainless steel tubing. Pressure tubes are used to convey fluids at elevated temperatures and pressures. Produced in stainless, carbon and alloy steels in sizes to withstand pressures up to 100,000 psi.

3. BOURDON TUBING

A "C" tube element for a pressure gage. The shaped Bourdon tube serves as the actuating element for the majority of pressure indicating and recording instruments. Helix and spiral elements are also fabricated from the wide range of alloys available at Superior—a range that makes it possible to satisfy any set of conditions in the use of Bourdon tubing.

4. CAPILLARY TUBING

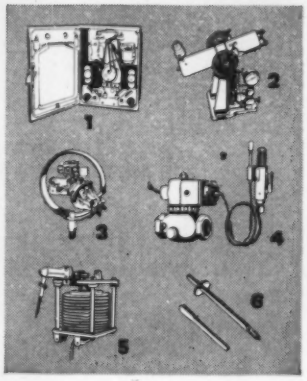
A thermostatic instrument pressure transmission element with a coiled unit made of Superior Type 321, capillary tubing. Superior capillary tubing is used primarily for transmitting temperature and pressure impulses from the source to a recording or indicating instrument. Capillary purposes, in general, require a heavy-wall tube with an ID of .006" to .030". Types 347, 321, 316, MONEL* and carbon steels are recommended analyses.

5. LARGE OD LIGHT WALL TUBING

A large OD light wall tubing bellows in a pressure actuating element. Present applications for large OD light wall tubing include bellows, low pressure heat exchanger tubes, flexible hose, aircraft ducting, fractional horsepower motor casings, ceramic drills, and casings for radioactive well logging instruments. Sizes offered up to 2½" OD.

6. MECHANICAL TUBING—INSTRUMENT LINE

Various fabricated parts—all made of Superior mechanical tubing. Superior mechanical tubing can be either seamless or WELDRAWN† grade used statically or dynamically, but not subjected to severe temperature or pressure. It is produced in sizes up to ⅝" OD within production limits, in many special shapes, and in over 63 standard analyses and mechanical properties.



Send for free copy of Bulletin 40—A Guide to the Selection and Application of Superior Tubing. Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to ⅝" OD—certain analyses in light walls up to 2½" OD

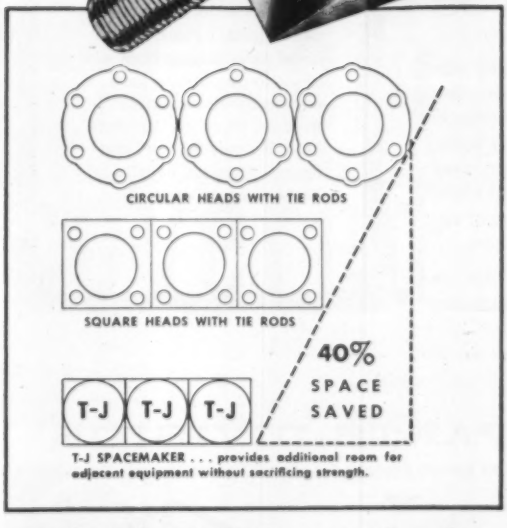
On the West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif.

*Reg. T.M. International Nickel Co.
†Reg. T.M. Superior Tube Co.

Saves 40% Space!

STRONGER, TOO

Than Outmoded Tie Rod Cylinders!



NEW LITERATURE... send today for new Bulletin with complete details of Spacemaker line.

Only T-J

Spacemaker CYLINDERS

Offer All The Extras As Standard!

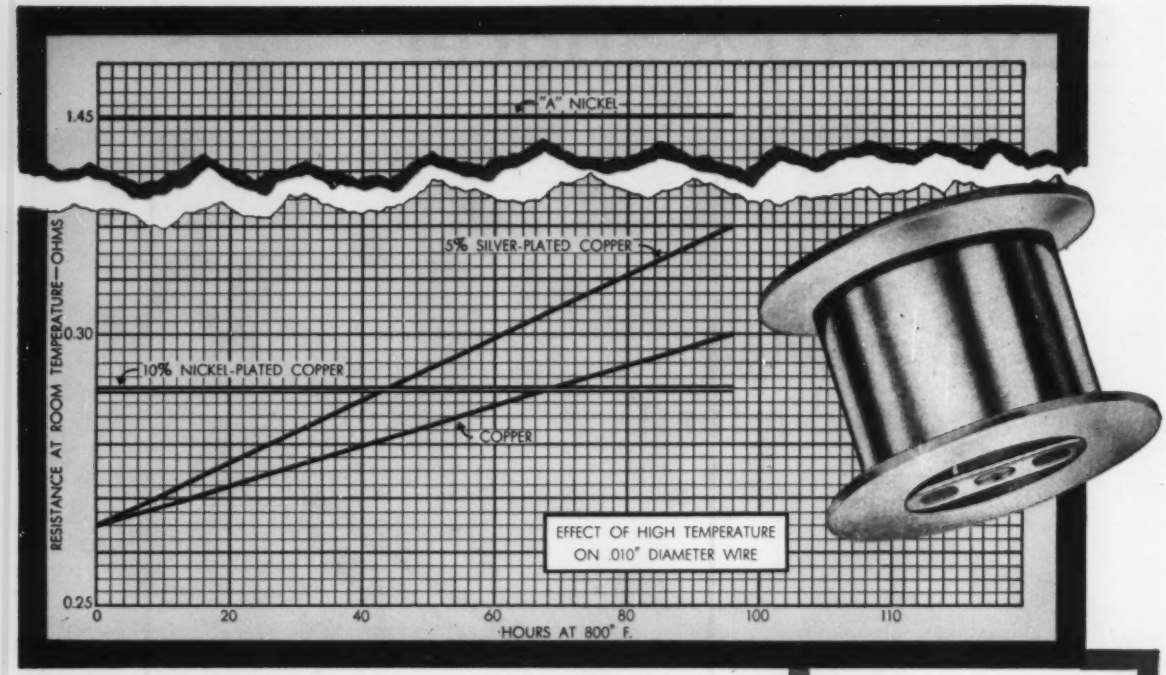
- **NEW *exclusive* Ingenious Cushion Designs... Super Cushion Flexible Seals for Air... New Self-Aligning Master Oil Cushion**
- **Compact design eliminates tie rods, saves up to 40% space**
- **Proven Performance . . . with Extra High Safety Factor**
- **Hard Chrome Plated Bodies and Piston Rods (Standard, at no extra cost).**
- **OIL pressure to 750—AIR to 200 P.S.I.**

You'll find many answers to *automation* in your plant with T-J Spacemaker Cylinders! Designed with years-ahead features for top performance and dependability. Wide range of styles, capacities . . . for all kinds of push-pull-lift operations . . . reduces man-hours and costs! Write The Tomkins-Johnson Co., Jackson, Michigan.

MEMBER OF THE NATIONAL FLUID POWER ASSOCIATION

T-J **TOMKINS-JOHNSON**

RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS



Nickel-plated copper...

for high conductivity at elevated temperatures

SYLVANIA's Nickel-plated copper wire combines the conductivity of copper with the corrosion-resistant properties of nickel for applications involving temperatures ranging from 350° Fahrenheit to 700° Fahrenheit.

Equal lengths of Nickel-plated copper and three other wires were heated in air at 800° Fahrenheit for an extended period to determine the effect of heat on conductivity.

Nickel-plated copper, more than any of the other wires except for pure nickel, holds its original low resistance. It's this feature which, in many cases, has made Nickel-plated copper more desirable than costlier wires used where conductivity must remain constant under high temperature environment.

Nickel-plated copper wire can be supplied in a full range of diameters from .250" to .005".

Sylvania is the only major wire supplier with complete facilities for plating and cladding wire. This makes it possible to provide you with an experienced, objective recommendation as to whether a plated or a clad wire is best suited for your application.

In addition, Sylvania's Parts Division offers you complete 4-way service including custom molded plastic parts, small metal parts ranging from wire forms to deep drawn parts, and special electronic components. Write for the "Portfolio of 4-way Service" and the new technical bulletin on Nickel-Plated Copper Wire.

SYLVANIA PARTS DIVISION

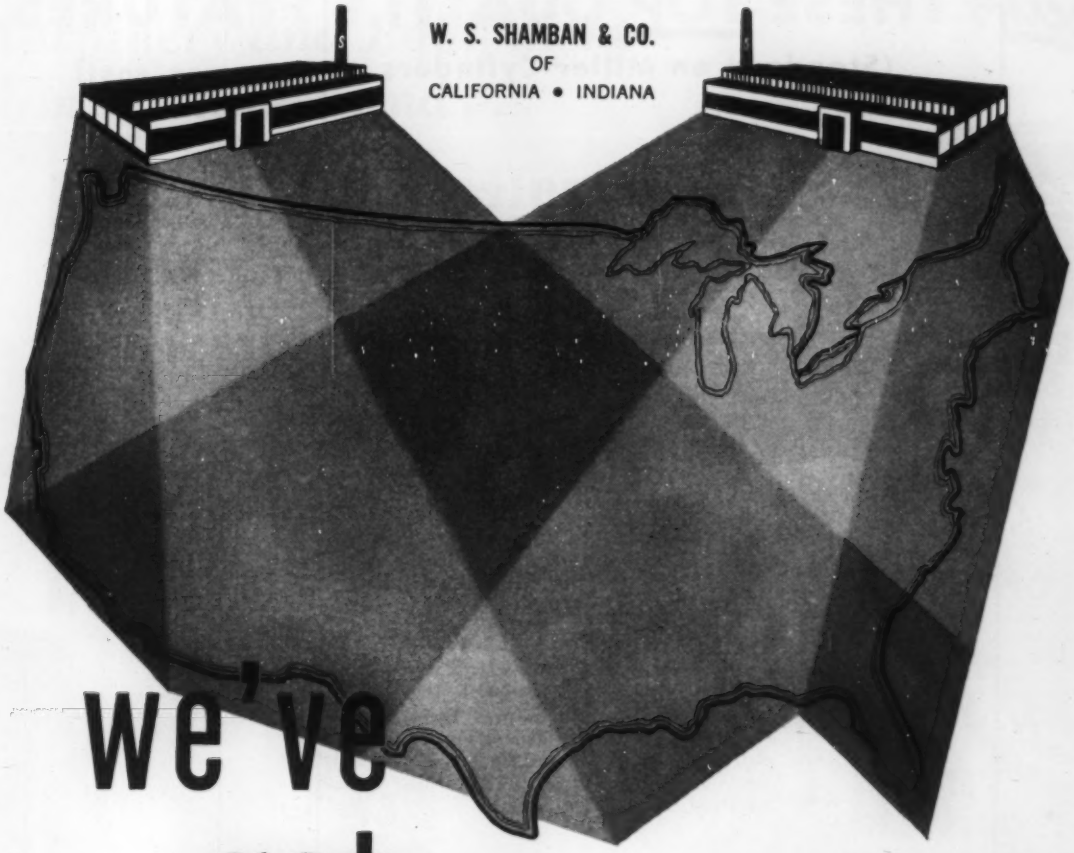
Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

4-way service from one source

Circle 456 on page 19

W. S. SHAMBAN & CO.
OF
CALIFORNIA • INDIANA



we've got 'em covered

Now — with our two great manufacturing plants under full production we cover every state in the 48 and Canada. The fact that we are manufacturing at two locations enables us to give better service and faster shipment of

TEFLON*...KEL-F** and FLUOROTHENE

Wide variety of standard sizes and shapes — rods — tubes — sheets — tapes — films — spaghetti tubing produced under rigid laboratory controls

Also available —
custom molding and extrusion — machining

Our integrated facilities allow strict control of all manufacturing operations from preparation of raw stock through fabrication of the finished product. Whatever your requirement — finished parts or raw stock —

Specify Shamban Teflon* — Shamban Kel-F — Shamban Fluorothene**

Write W. S. Shamban for nearest representative

*Du Pont Trademark
**M.W. Kellogg Co. Trademark

KELON

W • S • SHAMBAN & COMPANY

INDIANA — MEYER ROAD • FORT WAYNE 8 • ANthony 6491
CALIFORNIA — 11617 WEST JEFFERSON BLVD. • CULVER CITY • TExas 0-6877 • EXmont 7-2195

Guarantee TOP Performance and Maximum Life!

Specify THESE TOP QUALITY FEATURES...

(Standard on Miller Cylinders at no extra cost)

Specify CASE HARDENED CHROME PLATED PISTON RODS
On all Air and Hydraulic Cylinders

Benefits To You

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. ***Available from Miller at no extra cost.***

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. ***Available from Miller at no extra cost.***

Specify "TEFLON" WIPERS
On all Air and Hydraulic Cylinders

Benefits To You

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. ***Available from Miller at no extra cost.***

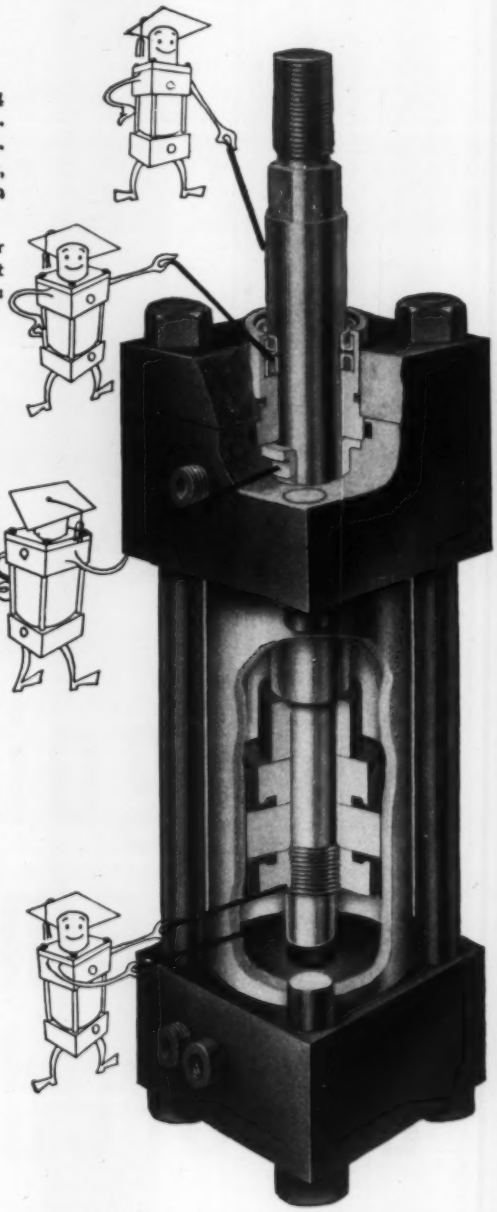
Specify TEFLON HYDRAULIC ROD SEALS
On all Hydraulic Cylinders

Specify RUST RESISTANT SURFACES
On all Air and Hydraulic Cylinders

Benefits To You

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)



You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

To (Dept.)_____

"On all our future cylinder requirements, please specify the above quality features."

Signed_____

Title_____

NOTE. On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard,* Piston Ring Seals are optional *at no extra cost,* and "Teflon" Cup Seals are available *at extra cost.*

Member of the National Fluid Power Association

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS
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DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • ATLANTA
TORONTO, CANADA and OTHER AREAS

Circle 458 on page 19

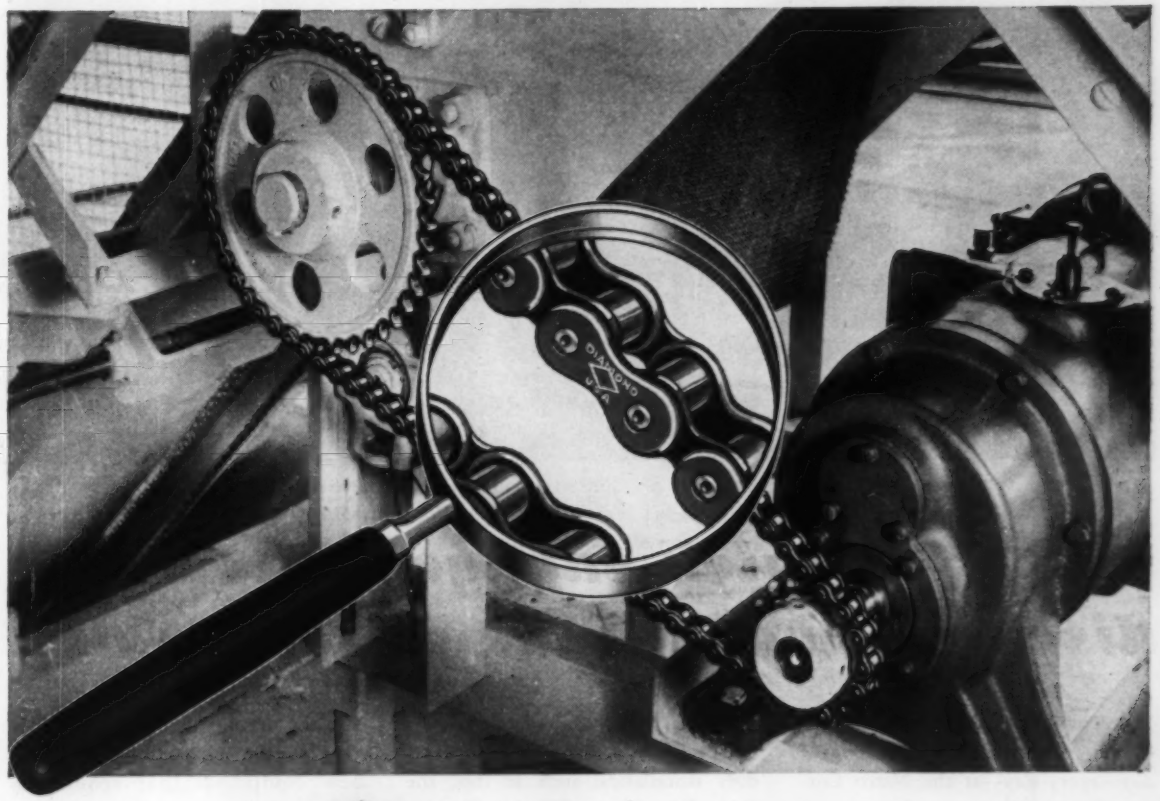
MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

2006 N. Hawthorne Ave., Melrose Park, Ill.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

Machinery and Equipment Manufacturers find . . .

Diamond Roller Chains Have Wide Acceptance Value . . .



The DIAMOND is the Mark of Uniform Quality

The more importance put on performance, the more important are the selections of machinery and equipment components.

Wherever power transfer and drives are employed, the uniform quality, long-life dependability and high maintained efficiency of Diamond Roller Chain insures the final performance.

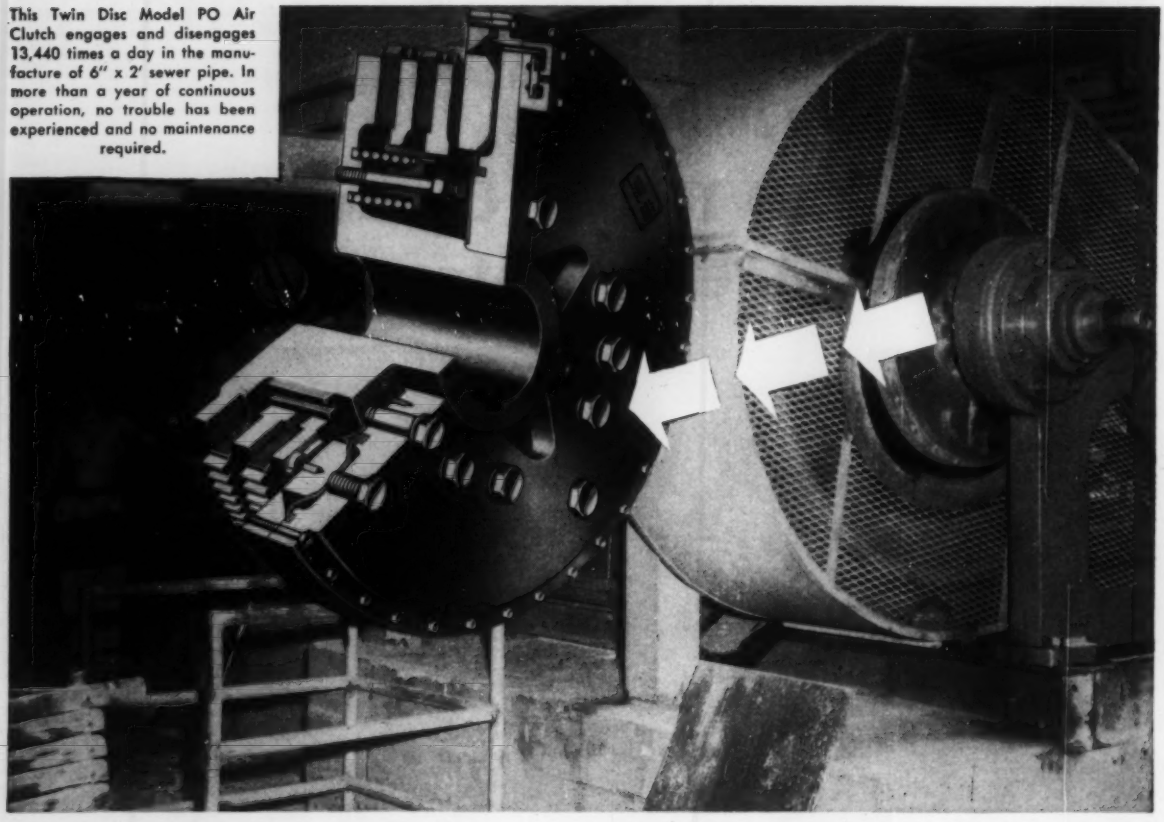
Wide acceptance for so many decades makes it a worthwhile asset. It's a good idea to look for the "Diamond" trade mark.

DIAMOND CHAIN COMPANY, Inc.
Where High Quality is Traditional
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana
Offices and Distributors in All Principal Cities

DIAMOND ROLLER CHAINS

Circle 459 on page 19

This Twin Disc Model PO Air Clutch engages and disengages 13,440 times a day in the manufacture of 6" x 2' sewer pipe. In more than a year of continuous operation, no trouble has been experienced and no maintenance required.



13,440 clutch engagements and disengagements a day...every day

A Twin Disc Model PO-224 Air Clutch *proves itself 13,440 times a day—every day*—at the Natco Corporation, leading manufacturer of clay sewer pipe, when 6" x 2' pipe is produced at their Brazil, Indiana plant.

This clutch is an *integral part* of a J. C. Steele Automatic Horizontal Extrusion Machine used to produce pipe in 4", 5", 6" and 8" sizes. For each pipe produced, the clutch engages and disengages to form the bell of the pipe and to subsequently extrude the proper length.

After more than a year of continuous operation, no trouble whatsoever has been experienced and no maintenance has been required.

Developed specifically for heavy-duty installation such as this, the Twin Disc Model PO Air Clutch's advanced design features offer many advantages, including *less shock loading* during starting cycles . . . *higher torque capacity* (up to 126,600 lbs. ft.) . . . *more compact installation* . . . *faster, smoother operation* under all working conditions; no seal drag . . . *positive, quick release*—provided by exclusive Twin Disc diaphragm design . . . *long, trouble-free operating life,* with extra-large air passages from cored backplate providing "air-flow" cooling to the diaphragm insulator plate, the springs and the driving plates.

If *you're* planning or designing new equipment that requires a lighter, more compact remote control of power transmission without complicated linkage . . . write *today,* for complete details on the Twin Disc Model PO Air Clutch. Request Bulletin 304.

TWIN DISC

TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division) Rockford, Illinois

Circle 460 on page 19

MACHINE DESIGN
February 7, 1957

Engineers and the Public

IN ONE of his whimsical "They'll Do It Every Time" cartoons, Jimmy Hatlo depicts a kitchenfull of household gadgets drawing straws to decide which one will conk out this Saturday. The plotting is done with malice aforethought. Company is coming and the repairman can't be contacted till Monday.

Too many householders will say "Boy, Hatlo sure hit the nail on the head this time!" But they know full well that, despite the cliche about the perversity of inanimate objects, the ultimate villain is human. The repairman has the answer on Monday: "The engineers didn't design it right."

Many of us are concerned about the public's acceptance of engineering as a profession. We bemoan the fact that the general public does not deal directly with engineers and therefore has no opportunity to judge their work. But we tend to forget that everyone owns and operates products of the design engineer's work—automobiles, lawnmowers, refrigerators, washing machines, vacuum cleaners, sewing machines, power tools, television receivers, to mention only a few.

Although he may not deal personally with engineers, the man in the street is well aware that they have made possible his proud ownership of that shiny new car or appliance. So every time one breaks down, no matter how minor the cause, the engineer gets a black eye.

Real cause of the failure is immaterial to the owner. It could result from incompetent design. It might stem from a misguided policy of cost-saving through specification of inferior materials or components. Either way, ultimate responsibility lies squarely on the design engineer's doorstep.

A primary attribute of a profession is service to the public. Also, it has been said that an engineer is a man who can do for a dollar what any fool can do for ten. So it is the engineer's challenge to build integrity into his design at a cost the public can afford to pay. That is his way of rendering service and earning public recognition for his profession.

Colin Carmichael

EDITOR

An Introduction to
Government Specifications

By M. Barov*
Standards and Standardization Dept.
Link Aviation Inc.
Binghamton, N. Y.

GOVERNMENT agencies, in the majority of instances, procure products built to requirements detailed in specifications or specification control drawings. When issuing "invitations to bid" on a contract, the pertinent specifications are listed by the procuring agency. This article is an introduction to the various kinds of specifications most often used at the inception of a contract for military products and throughout the design, production and testing stages. The need for specifications and their origins, identification and applications are discussed. Sources of copies are provided.

Need and Origin of Specifications

Government agencies rely on specifications for three principal reasons:

1. To assure that proper quality is maintained.
2. To simplify storage and stock control.
3. To assure sources of reliable replacements.

Specifications are particularly useful at the conclusion of the design phase, prior to production. Designs for new products may be examined to determine conformance to original requirements.

During design it sometimes becomes apparent that deviations from specifications are necessary. These deviations are usually concerned with components of end items and are requested on the following basis:

1. There is no specification to cover the desired parts.
2. Contract performance requirements differ from specification requirements.
3. Parts do not qualify under specifications cited.

In these instances, new or revised specifications are prepared and submitted to the applicable agency for approval. These documents, when approved, are normally acceptable only on the particular project and must be resubmitted for each new usage.

Waivers may also be granted when the use of MIL-approved parts delays delivery or increases cost. This is usually done in preproduction type contracts, and a provision is made for substituting standard parts if large-scale production occurs.

Preparation of Specifications

In the past, each government agency prepared

*Now with Farnsworth Electronic Co., New Haven, Ind.

Contents of Government Indexes of Specifications and Standards

Index of Specifications and Standards				Types of Specifications	Related Publications
Federal Catalog	Vol. II Army	Vol. III Navy	Vol. IV Air Force		
X	X	X	X	Federal Specifications	
	X	X	X	Military Specifications	MIL "Slash" Sheets MS-Sheets Qualified Products List Armed Service Electric Std.
		X	X	National Military Establishment	All Above
		X	X	Air Force-Navy Aeronautics Specifications and Bulletins	Air Force-Navy Aeronautical: Standard Drawings (AN) Design Standard Drawings (AND)
			X	Air Force Specifications and Bulletins	
		X		Navy Dept. Specifications, Navy Bureau Specifications including:	
		X		Bureau of Aeronautics Specifications	Navy Aircraft Factory Standards
	X			Army Specifications	

From design to delivery, products and materials for military departments of the government must conform to various specifications and standards. Basic background for designers is an acquaintance with these publications. This article is a check list of the types of specifications currently active.

its own specifications as the need arose. Existing specifications which had been prepared by other activities were sometimes used.

At the present time, specifications are prepared jointly by the Army, Navy and Air Force under the cognizance of the Department of Defense, Standardization Div. Certain specifications may be prepared initially by one of the services as "limited co-ordination MIL specifications" for the use of that service alone. These are eventually co-ordinated with the other services and, upon proper approval, are issued as "co-ordinated Military Specifications."

Federal Specifications usually cover items of interest to nonmilitary departments as well as the Armed Forces. A MIL specification may eventually be processed into a Federal Specification when the need arises for overall application of a product.

In most instances there is a long time lag between the development of a new product and the preparation of a specification by the military organizations. Amending or revising an existing specification is also complicated. In these instances, manufacturers and consumers of certain products may be requested to comment on changes.

To overcome this time lag, commercial specifications for commonly used products may be accepted by the Armed Services for procurement on an interim basis, and they usually serve as the base for the eventual service specification.

Alternative Commercial Standards

When no government specification exists, certain commercial specifications are permissible. The use of these standards and the order of preference is covered in the basic contract specification.

For example, ANA Bulletin 143d, "Specifications and Standards; Use of," establishes the order of

Classes of Specifications

Process specifications normally specify methods of test, criteria for proper design, or procedures involved with deliverable items. They deal with general classes of products and may detail the requirements for the classes or list the detail specifications for the procurement of items.

The contents of these specifications determine the type of materials and components to be used in particular product design.

Examples:

MIL-STD-202	Test Methods for Electronics and Electric Component Parts.
FED-STD-5(2)	Standard Guides for Preparation of Item Descriptions by Government Suppliers.
MIL-E-5272A	Environmental Testing Aeronautical and Associated Equipment.
ANA-143d	Specifications and Stds.; Use of.

Material specifications are concerned with properties of materials such as chemical composition or physical conformation.

This class of documents includes many Federal Specifications. Metals may be covered by the commercial specifications of such organizations as the SAE or AISI which are normally recognized by the Armed Services. For example, the specifications and standards in the SAE series, AMS, AS and ARP are all acceptable.

Examples:

QQ-A-411c	Aluminum Alloy 2S Bars, Rods, and Wire.
MIL-P-14D	Plastic—Materials, Molding, and Plastic—Parts Molded, Thermosetting.
MIL-R-6855	Rubber Synthetic, Sheet Molded and Extruded, for Aircraft Installation.

Product specifications define the properties that certain products must possess including test procedures and criteria of acceptability of such units. Product specifications may be compounded from process and material specifications although in many instances, materials may not be explicitly referenced.

Examples:

MIL-R-6106(ASG)	Relays, Electric, Aircraft.
MIL-R-93A(1)	Resistors, Fixed, Wirewound.

Index of Specifications and Related Publications

The Munitions Board, the Army, the Navy and the Air Force maintain separate indexes of specifications and related publications they use for procurement. Complete revisions of the indexes are issued semiannually and supplements are issued monthly. The principle types of specifications and related publications which appear in the indexes are:

Federal Specifications

Issuing agency is the Bureau of Federal Supply, and actual preparation is assigned to other federal agencies best qualified.

Federal Specifications have a three-part designation. The first part is a capitalized letter or letters denoting the group to which the specification relates. The second part is a single capitalized letter, the first letter of the title. The third part is a serial number within the alphabetical group. A lower case letter following the number denotes a revision, and a number in parentheses denotes an amendment.

For example, QQ-M-151a(4) is analyzed to be in group QQ covering metals, in class M for the title "Metals, General Specification for Inspection of," number 151 of this class, the first revision and the fourth amendment.

Military Specifications

These are prepared under the cognizance of the Department of Defense Standardization Div. and developed jointly by the technical services of the Army, the bureaus of the Navy, and the Air Force.

A Military Specification is identified by the capitalized letters MIL followed by the initial of the first word in the title and then by a number. A capitalized letter after the number indicates a revision and a bracketed number indicates a supplement. An abbreviation in parentheses after the number indicates that the specification is "unco-ordinated" and still under the cognizance of one agency.

For example, MIL-C-5040A-(ASG) (1) for Cord, Nylon is an unco-ordinated Military Specification, serial number 5040, revision A, amendment 1, under the cognizance of the Aeronautical Standards Group, Air Force and Navy Dept.

National Military Establishment Specifications

These were prepared under the cognizance of the Defense Supply Management Agency, Office of Standardization, and developed jointly by the technical services of the Army, Navy and Air Force.

Designation is similar to Military Specifications except that the symbol JAN is used in the first part. JAN specifications are being superseded by their MIL counterparts.

Air Force - Navy Aeronautical Specifications and Bulletins

These are prepared jointly by the Air Force, the Navy Bureau of Aeronautics, and the Aeronautical Standards Group of the Air Force and Navy.

SPECIFICATIONS are designated according to two different patterns. The original pattern had four parts: the symbol AN followed by the same pattern used in Federal Specifications.

The second pattern is a three-part code. First are the letters AN, second is the first letter in the title, and third is the serial number within the group. Revisions are indicated by a small letter, and amendments are noted by a dash or bracketed number after the serial number.

An example of the first pattern is AN-QQ-S-689a(1) for Steel, Nickel (2330) Bar and Rod. This is the Air Force-Navy Specification in federal group QQ, class S for steel, serial number 689, amendment coded for the group of metals, revision 1.

An example of the second pattern is AN-L-28-1 for Lamp, Red Coated Miniature Incandescent. This is the Air Force-Navy Specification for federal group L, Lamp, serial number 28, amendment 1.

BULLETINS list products which meet AN specifications and also provide information pertaining to specifications. They have a two-part designation: the letters ANA followed by a three-digit number. The number sequence starts at 100.

A typical bulletin is ANA-147L, "Specifications and Standards, Non-Government Organizations." Another is ANA-205d, "Knobs, Pointers," which lists products qualified under AN-K-3.

Air Force Specifications and Specification Bulletins

SPECIFICATIONS are issued by the Air Material Command and designated simply by a four or five-digit number. The letter X or Y preceding the number indicates a nonstandard item or tentative specification. Revisions are designated by a letter; amendments by a number.

Examples are: X-7303-A, "Radar Set AN/ARW-11A, Installation of," and 7460, "Noise Generator TS-195/GP."

BULLETINS are issued primarily to present information relative to specifications, and qualified products. They are designated by a two or three-digit number.

Examples of Bulletins are: "Bulletin 98, "Miscellaneous Requirements for Ground Electronic Equipment," and Bulletin 114, "Improved Electron Tubes, Use of."

Navy Department Specifications

These are issued by the Bureau of Supplies and Accounts of the Navy and prepared by the agency most concerned with the specification subjects. They are coded similarly to Federal Specifications except that the first part, which indicates classification, is a number instead of a letter.

For example, 47B2g identifies class 47, metals in plates and sheets, class B for the title "Brass, Commercial, Bars, Plates, Rods, Sheets and Strips," number 2 of the class, and revision g.

A Navy Specification will normally indicate the bureau or office having primary interest in the specification. This is indicated by a code letter following the identification.

Navy Bureau Specifications

Branches of the Navy may issue their own specifications as the need arises. Documents are designated OS for the Bureau of Ordnance, and RE or R for the Electronics Div., Bureau of Ships.

BUREAU OF AERONAUTICS SPECIFICATIONS are primarily intended for use on airborne equipment. They are identified by a two-part code. The first part is a capital letter or letters indicating the series. The second part is a number denoting the serial number in the group. A small letter indicates a revision and a dash indicates an amendment.

For example, SR-127b-2, "Aircraft Interior Lighting, Installation of," belongs to the SR series, Installation and/or Requirement Specifications. It is serial number 127, the second revision, amendment 2.

Army Specifications

These are prepared by the depart-

preference for nongovernment standards as follows:

1. Specifications listed in ANA Bulletin 147 and ANA Bulletin 343.
2. Standards established by standardizing technical societies and associations.
3. Commercial or company standards.

Two of the commonly used standards are:

Cross-Index of Chemically Equivalent Specifications: Designated Standardization Handbook H1A, this publication originates in the Office of the Assistant Secretary of Defense (Supply and Logistics), Standardization Div., Dept. of Defense. It contains a cross index of chemically equivalent specifications for ferrous and nonferrous metals. By the use of the index, it is possible to convert a particular material designation to the standard required by the procuring agency.

For example, if aluminum bar stock 24S were to be used, the subdivision Aluminum Producers' Designations would be consulted to obtain the code number 20024. This number is listed in Part I of the handbook, and all specifications with the same chemical analysis are listed opposite this number. Next, by associating the number with the proper form, which is bar, proper designations are the

ments within the Army most directly concerned. The designation consists of two or three groups of numbers separated by hyphens.

Examples are: 57-160, "Low and Rich Low Brass, Sheet and Strip" and 71-1762, "Radion Set An/APG-2."

Army Service Branch Specifications

Certain Army Corps prepare and release specifications which have the following code letters: CQD, JQD, KCQMD, QQMG, and PQD for Quartermaster Corps; EBP for Corps of Engineers; and SCL for Signal Corps.

Related Publications

MIL "SLASH" SHEETS form a part of MIL or JAN specifications but are published separately. They contain particular information on dimensions, configuration, electrical and/or mechanical characteristics which may be too varied to be included in the basic specification.

For example: MIL-E-1/1 through MIL-E-1/795 are "slash" sheets which make up the detail specification for MIL-E-1B.

MILITARY STANDARDS* are specification control drawings for standard parts. They may refer to procurement specifications or they may carry enough information themselves to properly control part fabrication. Military Standard sheets are designated with the letters MS followed by a series of numbers. Certain MS sheets, principally in the 33500 to 34999 group, are design standards and are therefore not used as part numbers.

*MS, AN, and AND drawings are not listed in the Air Force Index of Specifications. A separate publication is provided for these sheets.

AIR FORCE - NAVY AERONAUTICAL STANDARD DRAWINGS* are specification controls concerned mainly with components for airborne and associated usages. They may reference specifications or, in the case of less complex parts, they may specify parts completely. As these drawings are obsoleted, they are being superseded by MS sheets.

Designation consists of the letters AN followed by a serial number. Drawings AN-1 to AN-999 are used to describe standard parts and assemblies.

Note: In the numerical index, certain numbers have no AN prefix. These are Air Force drawings indexed as part of the AN list.

AIR FORCE-NAVY DESIGN STANDARD DRAWINGS* indicate the proper usages of standard parts. The sheets are recognized by the letters AND and have serial numbers from 10,000 to 20,000.

NAVAL AIRCRAFT FACTORY STANDARDS are issued by the Bureau of Aeronautics to describe Naval Aircraft standard parts. Drawings are identified by the letters NAFS and a serial number. The series starts with 1000.

QUALIFIED PRODUCTS LISTS give the names of vendors of materials qualified under the requirements of certain JAN or MIL specifications. The lists are recognized by the symbol QPL followed by the serial number of the specification and a dash number indicating the supplement.

For example, QPL-19-6 is supplement 6 to the Qualified Product List for JAN-R-19, "Resistors, Variable Wirewound, Low Operating Temperature."

ARMED SERVICE ELECTRO-STANDARDS AGENCY publications are concerned with the dissemination of design information in order to assist in the proper application and standardization of related components. Two of the principle publications are *Application Design Notes* and *Preferred Parts List*.

Application Design Notes (Electronic Components) contain the following: (1) a convenient breakdown of type designations for the parts list, (2) suggested applications including derating factors and other environmental limitations, (3) a listing of styles and types, including electrical characteristics, dimensions and mountings, and (4) a selected list of values which the Armed Services list as preferred values.

Preferred Parts List (Electronic Components) is partially included in the *Application Design Notes* and is also published as a separate, more up-to-date volume. The publication lists selected values to be used as standard values whenever possible. Also listed are the stock numbers assigned to preferred components by the various service branches.

Cancelled Specifications

A list of specifications which have been cancelled over some given period of time is usually included in an index of specifications. When superseding specifications are available, they may be listed with the cancelled specifications. It is advisable to examine a superseding specification to determine whether materials, processes or products it covers are interchangeable with those covered by cancelled specifications. Interchangeability is usually permitted for repair and replacement applications except where material itself has proved faulty.

Federal Catalog number QQ-A-268, the Military Specification number MIL-W-7986, or AMS-4120C which is an SAE specification acceptable as a non-government standard.

National Aircraft Standards: These take the form of specifications and specification control drawings on components and component parts which are standard in the aircraft industry. Normally, National Aircraft Standards are written to cover items not presently covered by existing official specifications. They are supposedly an interim standard to be used only until a government specification is released.

Agencies Issuing Specifications and Standards

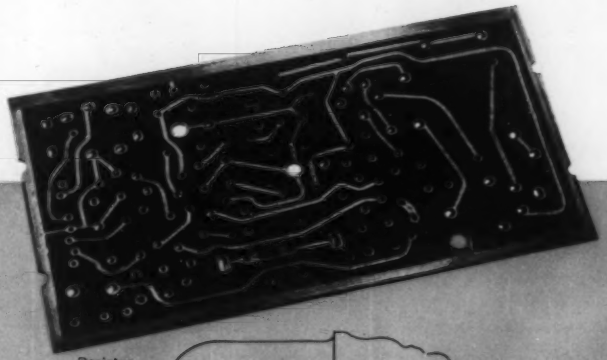
Procurement instructions will be found in the front of each Index of Specifications and Standards. All specifications, standards and bulletins may be obtained from:

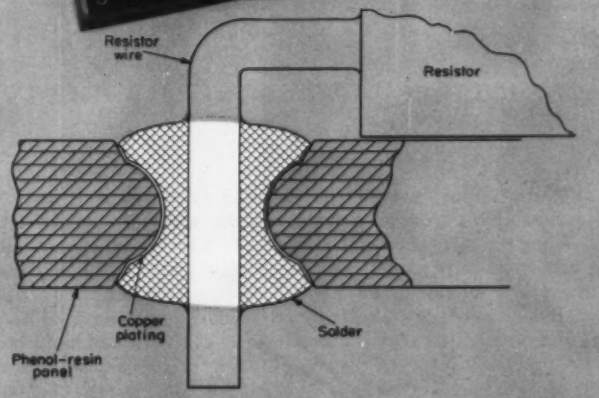
Superintendent of Documents
U. S. Government Printing Office
Washington 25, D. C.

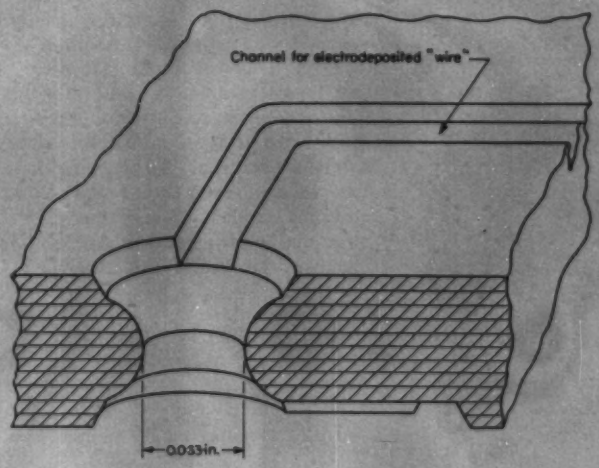
Also, nongovernment and nonmilitary offices may obtain copies of documents in the custody of the following departments, bureaus and corps from the addresses indicated:

Custodian	Address
Army:	
Chemical Corps	Commanding General Chemical Corps Materiel Command Attn: Industrial Div. 200 West Baltimore St. Baltimore 1, Md.
Corps of Engineers	Chief of Engineers Department of the Army Attn: ENGHP Washington 25, D. C.
Medical Corps	Chief, Armed Services Medical Procurement Agency Development, Engineering and Standards Div. Development Branch Fort Totten 59, N. Y.
Ordnance Corps	Chief of Ordnance Department of the Army Washington 25, D. C. or: nearest Ordnance District Office
Quartermaster Corps	Commanding General Philadelphia Quartermaster Depot 2800 South 40th St. Philadelphia 45, Pa.
Signal Corps	Commanding General The Army Signal Supply Agency 225 South 18th St. Philadelphia 3, Pa. Attn: SIGSU-J46
Transportation Corps	Commanding General Transportation Supply and Maintenance Command P. O. Box 209, Main Office St. Louis 3, Mo.
Navy:	
Primary source (Except Bureau of Aeronautics specs.)	Commanding Officer Naval Supply Depot Scotia 2, N. Y.
Secondary sources: Bureau of Aeronautics	Chief, Bureau of Aeronautics Technical Data Div. Department of the Navy Washington 25, D. C.
Marine Corps	Commandant, U. S. Marine Corps Code SCG Headquarters U. S. Marine Corps Washington 25,D. C.
Bureau of Medicine and Surgery	Chief, Armed Services Medical Procurement Agency Development, Engineering and Standards Div. Development Branch Fort Totten 59, N. Y.
Bureau of Ordnance	Chief, Bureau of Ordnance Attn: Chief Engineer (Rec) Department of the Navy Washington 25, D. C.
Bureau of Ships	Chief, Bureau of Ships Attn: Code 357 Department of the Navy Washington 25, D. C.
Bureau of Supplies and Accounts	Chief, Bureau of Supplies and Accounts Attn: S-33 Department of the Navy Washington 25, D. C.
Bureau of Yards and Docks	Chief, Bureau of Yards and Docks Attn: Code C-330 Department of the Navy Washington 25, D. C.
Air Force	Commander Air Materiel Command Wright Patterson Air Force Base Ohio Attn: MCSIFS-31
Federal:	
Primary source	Business Services Center General Services Administration Washington 25, D. C.
Secondary sources	Director, Business Service Center General Services Administration:
States of Me., Vt., N.H., Mass., Conn., R.I.	620 Post Office & Court House Boston 9, Mass.
States of N.Y., N.J., Pa., Del.	250 Hudson St. New York 13, N. Y.
D.C., Virgin Is., Puerto Rico; States of Md., W.Va., Va.	Regional Office Bldg. 7th and D Sts., S. W. Washington 25, D. C.
States of N.C., S.C., Tenn., Miss., Ala., Ga., Fla.	Room 844 Peachtree-Seventh Bldg. 50 7th St., N. E. Atlanta 5, Ga.
States of Ky., Ill., Wis., Mich., O., Ind.	Room 575 U. S. Courthouse 219 South Clark St. Chicago 4, Ill.
States of Miss., Kans., N.D., Iowa, S.D., Minn., Nebr.	Gen. Serv. Adm. Bldg. 2306 East Bannister Rd. Kansas City 14, Mo.
States of Tex., Ark., La., Okla.	1114 Commerce St. Dallas 2, Tex. Room 2169 Federal Center 300 West Vicory Fort Worth 2, Tex.
States of Colo., Utah, Wyo., N.M.	Bldg. 41 Denver Federal Center Denver 1, Colo.
Hawaii; States of Calif., Ariz., Nev.	4th Floor 49 Fourth St. San Francisco 3, Calif. Room G-20 U. S. Post Office & Courthouse 312 North Spring St. Los Angeles 12, Calif.
Alaska; States of Wash., Oreg., Mont., Idaho	Federal Office Bldg. 909 First Ave. Seattle 4, Wash. 201 U. S. Courthouse (New) Broadway and Main Sts. Portland, Oreg.

scanning the field for *Ideas*



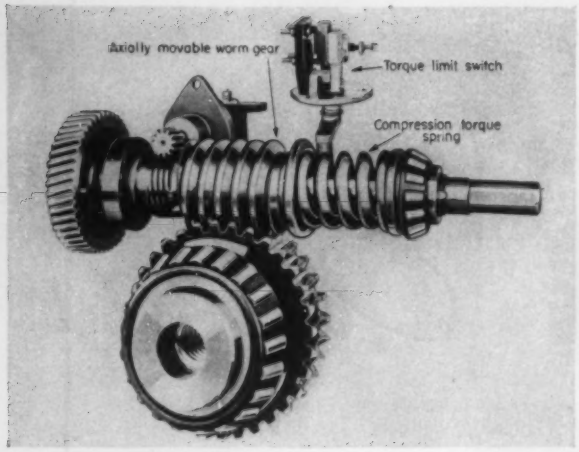


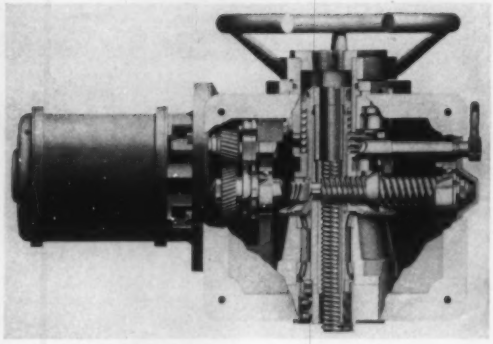


HOURGLASS-SHAPED HOLES provide a secure, positive method of locking solder nuggets surrounding component wire terminals in electronic circuit asemblies. Applied in the design of plastic panels for printed circuits introduced by Die Form Circuits Inc., the holes are molded in the panels and eyeletted with a copper deposition which is in turn covered with a coating of solder. The hourglass cross-section of the holes, which are relatively large, permits automatic insertion of wire terminals on components. The design eliminates the need of crimping component terminals either for purposes of holding or to effect soldering.

Wiring circuitry between holes is molded in channel form on one or both sides of the panel at the same time the holes are molded. These channels are partly filled with electrodeposited copper and coated with solder concurrently with plating the holes.

IDEAS

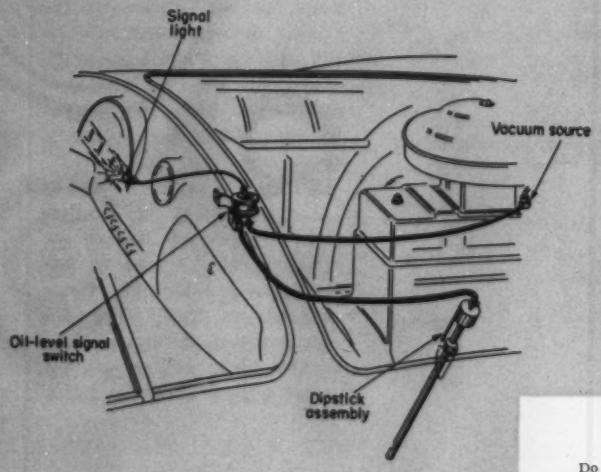




ACCURATE TORQUE-LIMIT CONTROL of hydraulic valves is provided by a novel mechanical thrust-sensing system. In motor-driven "packaged" valve controls manufactured by Philadelphia Gear Works Inc., axial movement of a spring-loaded worm gear is used to actuate a torque limit switch connected in the drive-motor power circuit. The motor is automatically de-energized when a certain predetermined maximum load is encountered in the LimiTorque units.

The torque switch is provided with micrometer calibration permitting accurate adjustment of valve seating thrust. Also, this switch automatically breaks the motor circuit if an obstruction is met while the valve is closing.

AUTOMATIC LIQUID-LEVEL MONITORING is accomplished by a novel electro-pneumatic control system. By means of a so-called electric dipstick developed by King-Seeley Corp., minimum safe oil levels in internal combustion engines are automatically indicated by a signal warning light on the operator's control panel.



In design the dipstick consists of a hollow tube with a hole located near the lower end just below the "add-oil" line. The top of the dipstick is connected by a hose to the vacuum chamber of a vacuum-operated switch. This switch is, in turn, connected by a length of hose to a vacuum power source at the intake manifold.

As long as the oil level in the engine crankcase covers the hole at the bottom of the hollow dipstick, a vacuum can be applied to the switch which will open its contacts and turn off a low-oil-level indicator lamp. However, if the dipstick hole is uncovered, air bleed will neutralize the vacuum developed, permitting the switch contacts to close and light the warning lamp. The vacuum switch and dipstick are designed to limit the value of vacuum applied to prevent sucking oil up into the intake manifold.

Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas," MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

How to apply

COLOR IN DESIGN

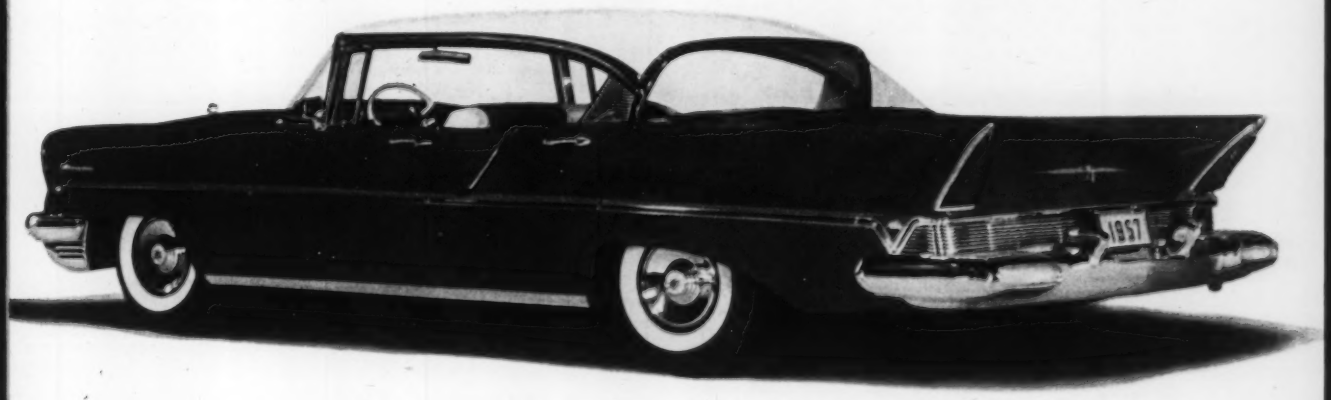
By Howard Ketcham
Color and Design Engineer
New York

Color planning can affect not only appearance but also market acceptance, ease of operation, usefulness and cost of machines, instruments and equipment. Successful integration of color with design requires a good basic understanding of color fundamentals, complementary colors, good and bad color combinations, the effects artificial light sources have on color, etc. These factors combined with knowledge and experience of customer preferences can affect the selection of type and number of colors in a product line. This article presents a host of ideas for properly applying color in design, and predicts future trends in color.

IN PLANNING color specifications the designer must analyze and meet two basic requirements. First, will the colors serve a functional or utilitarian role, that is, will they add to the product's usefulness or improve its operation? Second, will the colors have the widest esthetic appeal? In working with color in design, obviously its emotional effects must be considered. But in planning and applying color in the design of machines, instruments, or other pieces of equipment, the emotional factor is only one of several considerations. The designer must be concerned not only with how the user or worker is likely to feel about certain color relationships, but also—and this is perhaps even more important—with how well the user can see and how critical or difficult the seeing requirements are.

Good color can affect a product in several ways,

This striking 1957 Lincoln is the result of expert car styling combined with careful color selection. A good line of colors plus good design helped Lincoln greatly increase sales in 1956 over 1955.



and here are six important ones that the designer should remember:

1. **Color improves ease of operation.** For example a drill press with moving parts in correct contrasting colors is easier on the eyes and therefore easier to operate; it affords a greater degree of safety.
2. **Color influences manufacturing costs.**
3. **Color signifies the quality, grade, size and purpose of a product.**
4. **Color increases the scope of usefulness of a product.**
5. **Color makes products easy to locate and identify.**
6. **Color improves appearance and market acceptance.**

Appearance improvement is the most obvious target of color application, for today, with workmanship, quality and price so equal, good color appearance is the important factor in the success or failure of many products. Sometimes it is difficult to evaluate the color appearance factor for a product without recourse to extensive and exacting market surveys, since many consumers, especially men, do not like to admit that they judge products by their looks.

Product design can never be hurt by good color planning. Neat, appropriate, distinctive and well-placed color arrangements result in a coherent impression. This provides a decided competitive advantage and generally at small extra cost. Furthermore, it is usually easy to improve a product's appearance through skillful color application without altering the product's performance, usefulness or ease of operation and maintenance. Color can induce people to pay a premium price for a product and color, properly selected and properly introduced, can make an inexpensive product look more costly.

In improving product appearance through the application of color, the designer should obtain answers to the following questions:

1. **What is the function of the color plan?**
2. **What are the conditions of the product's use?**
3. **What colors do competitors employ?**
4. **Where will colors be applied on the product?**
5. **What psychological relationships are involved between customer and product?**
6. **What background colors at point of sale require consideration?**
7. **Under what lighting will the colors be viewed?**

Better Marketability with Color

Color styling and recoloring of products in most instances insure better marketability. All salesmen, dealers and distributors have a substantial stake in the marketability of any product they handle; they must know the facts relating to the helpful and hindering aspects of a color line. Customers buy certain colors and reject others, and management must keep properly and promptly posted on customer color preferences. Product color changes are sometimes costly and complicated, yet management can, through the intelligent and correct anticipation of customer color wants, frequently achieve better sales results—with less expense — through adroit color revision than through far more costly design changes.

Only a few of the wavelengths which comprise the electromagnetic spectrum can be seen by the human eye. Red is at one end of this visible spectrum, violet at the other. Wavelength of violet light is 16 millionths of an inch and red is 32 millionths of an inch.

Hue, Saturation, and Value: The central portion of each grouping in the visible spectrum produces a pure color or *hue*. Hue is defined as the quality that enables us to distinguish one color from another, to tell red from green for example, or blue from yellow.

A pure color, one that has no other colors in it, is called a *saturated* color. An olive green, which has gray in it, is a less pure green than an emerald green, for example.

The way a color really appears to the eye is not only affected by saturation but by brightness or value. A light color can be distinguished

Table 1—Light Reflection Factors of Colors

Color	Light Reflection Factor (per cent)
Light Ivory	78
Yellow	72
Light Green	51
Light Blue	40
Gray-Brown	20
Dark Red	15

Table 2—Principal Complementary Colors

Yellow and Violet	**Red-Orange and Blue-Green**
Yellow-Orange and Blue-Violet	**Red and Green**
Orange and Blue	**Red-Violet and Yellow-Green**

Table 3—Color Combinations

Good Combinations	Bad Combinations
Scarlet and Turquoise	Scarlet and Green
Scarlet and Blue	Scarlet and Yellow
Vermilion and Blue	Scarlet and Violet
Orange and Blue	Orange and Purple
Red-Orange and Blue-Green	Yellow and Bright Red
Golden Yellow and Blue	Lime Yellow and Turquoise
Lime Yellow and Blue	Green and Purple

Table 4—Standard Color Code for Piping

Red: Fire protection including sprinkler systems.
Yellow or Orange: Dangerous materials both inflammable or poisonous.
Green, White, Black, Gray or Aluminum: Safe materials.
Light Blue: Protective materials, such as antidotes to poisonous fumes.
Purple: Valuable materials.

A manufacturer's sales department needs product colors that will serve as a tool to build demand for his product. For example, machine tools and factory equipment require colors that promise more efficient operation — colors that improve morale, speed and accuracy and decrease absenteeism and accidents. In planning colors of products, the designer must have considerable data on color,

Color Theory and Color Design Data

from a dark one by the quality of *value*. Value tells how light or dark a given hue is. For example, pink is a high-value red whereas maroon is a low-value red.

Reflection Characteristics: Light reflection is a primary color consideration for the designer. Color selection for machines, equipment and work areas is determined largely by the light-reflecting characteristics of the various colors available, Table 1.

Only a certain percentage of the light that strikes a surface is reflected away; even the best white paint reflects only 83 per cent of daylight.

Complementary Colors: One of the most important and useful color relationships is that of complementary colors—two colors which between them contain all three primary colors (red, blue and yellow). The principal complementary colors are listed in Table 2.

Pure complementary colors, when arranged adjacent to each other, tend to intensify each other. For example, red looks redder when superimposed upon a green background and, correspondingly, the green looks greener. A red letter on top of a green colored machine will be difficult to discern because the outline of the letter will tend to blue due to the visual aberration set up by the strong contrast where the two colors join. To alleviate this, a lighter variation of the background color should always be used as an edging for lettering superimposed on a complementary color.

Color Combinations: Product color combinations are quite important to the designer. Seven examples of good and bad product-color relationships are shown in Table 3.

Color Identification: It is often possible to color code parts of machine and other equipment for ease of maintenance and for safety purposes. It may help prevent expense and injury to workers and increase their efficiency. For example, coding of piping colors has been established by the American Standards Association, Table 4. Color coding for piping really pays off in worker safety and efficiency because it gives him a quick clue as to type of liquid a given pipe carries.

Effects of Light on Color: A constant problem in developing product colors is color matching. North light from a cloudy sky is best for the job, because it is more diffused, except in the southern hemisphere where color matchers fare better with south light.

No matter what product colors are selected or developed, the typical lighting in which these colors are viewed has a strong effect on how they will look. Table 5 lists the effects various artificial light sources have on product colors. The effects of lighting further depend, of course, on the product's material and surface texture or finish of the object. Some artificial sources of light are lacking in one or more elements of the spectrum; for example, there is no blue in incandescent light. Therefore, artificial lights often produce inadequate or exaggerated color effects as Table 5 shows. Using an improper light source can give a false color impression. For example, a daylight fluorescent light, which is weak in red components and strong in the blue-green end of the spectrum, will make a red product fall short of its true color potential.

Table 5—Appearance Ratings* of Colors under Artificial Light Sources

	Fluorescent Lamps					Incandescent Lamps
	Daylight	Standard Cool White	Deluxe Cool White	Standard Warm White	Deluxe Warm White	
Maroon	Dull	Dull	Dull	Dull	Fair	Good
Red	Fair	Dull	Dull	Fair	Good	Good
Pink	Fair	Fair	Fair	Fair	Good	Good
Rust	Dull	Fair	Fair	Fair	Fair	Good
Orange	Dull	Dull	Fair	Fair	Fair	Good
Brown	Dull	Fair	Good	Good	Fair	Good
Tan	Dull	Fair	Good	Good	Fair	Good
Golden Yellow	Dull	Fair	Fair	Fair	Good	Good
Yellow	Dull	Fair	Good	Good	Dull	Fair
Olive	Good	Fair	Fair	Fair	Brown	Brown
Chartreuse	Good	Good	Good	Good	Yellowed	Yellowed
Dark Green	Good	Good	Good	Fair	Dull	Dull
Light Green	Good	Good	Good	Fair	Dull	Dull
Peacock Blue	Good	Good	Dull	Dull	Dull	Dull
Turquoise	Good	Fair	Dull	Dull	Dull	Dull
Royal Blue	Good	Fair	Dull	Dull	Dull	Dull
Light Blue	Good	Fair	Dull	Dull	Dull	Dull
Purple	Good	Fair	Dull	Dull	Good	Dull
Lavender	Good	Good	Dull	Dull	Good	Dull
Magenta	Good	Good	Fair	Dull	Good	Dull
Gray	Good	Good	Fair	Soft	Soft	Dull

***Appearance Rating Key**

Good—Color appears most nearly as it would under an ideal white light source such as north sky light.
Fair—Color appears about like it would under an ideal white light source but is slightly less vivid.
Dull—Color appears less vivid.
Brown—Color appears to be brown because of small amount of blue light emitted by lamp.
Yellowed—Color appears yellowed because of small amount of blue light emitted by lamp.
Soft—Surface takes on a pinkish cast because of excess of red light emitted by lamp.

These ratings are based upon subjective appraisals as compared to how the color would look under a nearly ideal white light source, such as north sky light. Although these values apply to standard General Electric lamps, they are representative of the industry.

The ultramarine-blue and orange design (top) for Jersey Central diesels combines attention-getting brightness with good durability. The color plan raised the problem of developing an ultramarine pigment that would stand up in service. This problem was solved through the use of a special synthetic finish. The Florida East Coast Railroad's locomotive color plan (middle) helped win a law-suit. A court used evidence of the locomotive's high visibility as one factor in finding for the railroad in a grade crossing accident. Colors used on Southern Railway diesel (bottom) are attractive in appearance and provide good trademarks for the railroad.

and specific facts on customer psychology, current taste, conditions of production and the uses to which the individual product will be put.

Changing conditions often compel the adoption of radically different color schemes on manufactured products—another example of the close tie between color and marketability. When functional color schemes were adopted in progressive business offices, business machines in staid and conservative gray, black and olive drab looked out of place and became out of date and, of greater interest to the maker, out of demand. Colors in kitchen walls increased the clamor for color in home appliances. One stove manufacturer introduced compatible colors and realized 38 per cent of his sales in color during the next 6 months.

With this burgeoning use of color for home appliances and office equipment, more and more products are being revitalized by successful color engineering. Telephones are a case in point; they followed the typewriters, adding machines and refrigerators in their break from traditional black and white. The once universal black phone will probably never be obsolete; however, ever since cheerful phone colors—colors developed by the author—were first introduced, they have been acclaimed as a wonderful new method of adding accent color appeal to homes and offices.

Redesigning with Color

It is always worthwhile to try to enhance the visual value of a product; with a change in color the product can be offered as an improved version. Redesign entails the heavy expense of tool and die changes while color change is a proven sales-and-profit-producing and less expensive step. Colors imparting a look of quality frequently overcome the natural sales resistance to the same product designed with poorly selected colors. Even a quality product may suffer from customer neglect if color planning and selection is not careful.

There are, of course, a few qualifications to

the use of new color as a sales tool. Up to a certain point, the competitive position of even a badly colored piece of equipment will improve as the price is lowered; there is, however, a portion of the market that will not buy poorly finished and colored merchandise regardless of price. On the other hand, some color finishes and effects, while superior in sales appeal, are so expensive to apply that they increase cost beyond the point of marginal utility. Moreover, there are naturally some industries where product color is not a problem and cannot be used to improve market acceptance; there is, for example, virtually no need for a colored sewing needle.

Factors in Color Planning

The entire problem of color selection involves familiarity with the psychology of color and basic relationships in physics, chemistry, psychophysics, physiology, and even philosophy.

From a psychological standpoint, red is the color used to indicate high temperature or danger. Red, since the time of primitive man, has been associated with heat and action in human thought and emotions. On the other hand, for physical and physiological reasons a yellow background is used to make black or dark threads more easily visible in some textile machines. The eye perceives more readily when bright yellow and black set each other off than with any other color combination.

Closely related to these psychological and factual considerations in planning color are those of color harmony and association. Both deal with individual reactions to color. Colors are in harmony when, in the opinion of colorwise people, they enhance each other visually. People appreciate happy color relationships; they know when colors are right and sense when they are not.

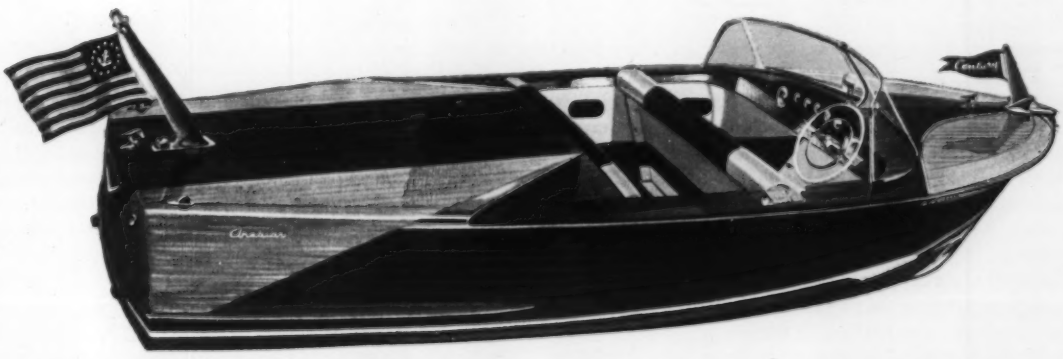
Color association is another and even more individual reaction to color; everyone associates colors with certain occasions, events, purposes or uses. A woman may like the color pink because of early flattery for her first pink dress.

Reactions of people to color—the dual reactions of harmony and association—vary widely on the basis of geography, age, sex and time. A certain yellow once favored in the southwestern United States as a bright and sunny color for room interiors was rejected in other regions as being too gaudy. A study made some years ago found that families of Italian extraction favored mother-of-pearl, tan and blue-green for refrigerators; other national groups preferred different colors. Color preference by car buyers shows a strong correlation with the country's economic condition. During bad times car buyers buy the conservative and serviceable colors—black and dark shades; as times get better, brighter car colors move into the lead.

Color contrast is an important factor in product color planning. One leading manufacturer of power saws introduced a new saw incorporating a color finish specifically designed to be distinctive from those of his competitors and to contrast well with an outdoor setting. Four major competitors had developed their color plans around orange, chrome yellow, royal blue and stipple-finish gray, respectively. The manufacturer saw that eye-catching Chinese vermilion was distinctive and stood out well against the outdoor background. Coupling that color with a chrome finish on handles, guide bar and chain provided good color contrast, greatly improving safety and visibility.

Color contrast is not always desirable, however. The strong contrast of some basic colors can slow factory production, in many cases, if applied to the work surfaces of factory machinery requiring close and constant supervision. Strong basic colors in powerful close-contrast relationships, such as strong red and green or blue and orange, tend to tire the eyes.

Correct color can sometimes increase the mechanical efficiency of a product. A good example comes from the U.S. Bureau of Standards where they conducted tests on the heat-radiation prop-



One of the Century Boat Company's fastest selling new "Arabian" yachts. Boats are shedding their traditional color schemes and are blossoming out in a rainbow of new seagoing colors. Boat builders, like automobile makers, are giving customers a wider choice of colors including two-tones.

Howard Ketcham, an expert in color, design and illumination engineering, has been in constant contact with design problems dealing with the inter-relationship of color and the machine. During his years of experience as head of Howard Ketcham Inc., he has developed color plans for automobiles, fountain pens, railroad locomotives and cars, telephones, and caskets. His plans have been reflected in increased sales of products as diverse as gasoline, toothbrushes and yachts. Mr. Ketcham's clients include Pan American World Airways, Cities Service Oil Co., United States Steel Homes and many others. He is the author of a number of books on color; his latest, *Color Planning in Business and Industry*, will appear soon.

erties of various finishes. The Bureau found that a white radiator with five sections radiates just as much heat as a six-section radiator painted aluminum or bronze. The proper finish boosts the heating efficiency of the radiator by as much as 17 per cent.

Selecting Durable Colors

Colors should not only be suitable from the standpoint of appearance, but they must also be durable. One seldom sees purple or lilac-colored machines because these two colors, like certain others, will fade.

Diesel locomotives, for example, are notably quiet—so quiet that people have been killed on the tracks because they did not hear a diesel's approach. To help overcome this danger hazard for the Central Railroad of New Jersey a color plan was developed for its diesel locomotives to make them highly conspicuous. The problem became one of determining what combination of pigments would produce the most distinctive and appropriate arrangement, and yet be economical from the standpoint of durability.

Ultramarine-blue and orange made a distinctive combination with high and long-range visibility. A good strong orange was not hard to create, but the ultramarine blue proved impractical in a conventional lacquer vehicle because the acid action of nitrocellulose in the vehicle tended to break down the ultramarine pigment and turn it white. The eventual solution required the adoption of a synthetic finish containing an acid acceptor, the components of which did nothing to the detriment of the ultramarine.

Price is not in itself a criterion of the durability of paint. For the same color in finishes of comparable quality and durability there may be a price spread as great as 20 per cent. On the other hand, extremely durable Hansea yellow sells for approximately four times as much per pound as considerably less durable chrome yellow. Fortunately, with the guidance today of the directives and performance tests regarding pigments and vehicles established by the Federal Government and other standardizing groups, the price spread can be reduced among the different suppliers of comparable quality finishes. During the war certain Naval establishments found wide discrepancies in paint costs listed by various manufacturers; it was not until paint specifications were established against which bids were invited that the Navy was able to reduce the spread in its paint buying to 5 per cent. Specification of ingredients and performance tests can serve as a protection against low quality finishes, too, the price of which can be tempting but whose serviceability will usually be brief.

Benefits of Good Machine Colors

Color can be profitable in the factory and farm as well as in the home and office. The benefits of intelligent use of color on factory machines, for example, are positive for both employer and employees. Here are some of the results obtained with the correct use of functional color or machines: Better morale, greater safety, more efficiency, less waste, reduction of nervous tension and eye strain, better workmanship, high output, less absenteeism, fewer accidents and better labor-management relationships.

Through the use of colors on machines that will help focus the eye on working parts, employees can see their work better. Where eye strain is reduced, physical fatigue goes down accordingly; where physical fatigue is reduced, worker efficiency is increased. In a New York precision tool

plant, the proper co-ordination of color in machinery and work areas cut absenteeism 40 per cent and increased production 15 per cent.

Color can be employed advantageously on large, heavy objects that need to be moved from place to place in a work area. Ask a shipping clerk to move one of two objects of equal size, one painted pale blue and the other painted dark brown. He will start for the item of the paler color. Why? Because the pale color gives the impression that it is lighter in weight. Tell the clerk to move the item to a red table or a blue table, each 20 ft away. He will move it to the red one; the red table seems a full step closer.

Correct color can also increase efficiency on jobs requiring precision measurement and accurate reading of information. Several manufacturers, for example, are developing radar equipment in which targets of interest appear in one color, stationary objects like land masses in another, and the face of the scope in still a third; one obvious application of this new equipment is in controlling the high-speed and high-density air traffic surrounding the modern air terminal.

Factors Affecting Number of Colors

Should a manufacturer use a few well-chosen basic colors or try to bring out his products in

Future Trends in Color

In recent years, color has made dynamic strides in design. It is today a recognized method of increasing efficiency, improving function and boosting sales. This burgeoning use and understanding of color will continue to grow. Here are some examples:

Automobiles: New car colors will be softer and more conservative in contrast to some of the gaudy combinations seen over the last 2 years. The dull depression favorites, colors of black and dark blue, gave way to a veritable rainbow of car finishes after World War II. Now these colors are meeting the test of the marketplace, and the consumer's dollar is making its color preference felt. Color there will be, but riot no longer. The drivers of the late 1950's will drive with decorum, not dazzle.

Aircraft: The new passenger jets are on their way, even now shaping up at Boeing, Douglas, Lockheed and Convair. It is a good bet that their high speeds and steeper angles of descent will eventually dress these jets in the same high-visibility colors that the Navy and Air Force now prescribe for training planes and air-sea rescue craft. With traffic density still growing over our airports, exterior color is going to become an important factor in cutting the hazard of plane collision.

In their interiors, these planes will continue to use color to minimize the innocuous cigar shape of their fuselages and to create separate visual areas. They will also employ color to increase interior light reflectance. One of the current problems in commercial aircraft is the incongruous combination of a near-sonic performance with model-T lighting.

Home Appliances: The color revolution in home appliances is already with us. In the future manufacturers most likely will color-plan not only for product compatibility within their lines, but also for compatibility with the bright and colorful homes of the future. Many homes will utilize colorful, plastic interior-finishing materials for walls and ceiling in a few years.

Boats: In boats the same increased use of color as a sales tool will prevail that appears in the automobile industry today. The man who buys a two-tone car is more likely a sales prospect for a two-tone boat. The Century Boat Co. recently had their colorful Coronado cruiser carefully color-planned and designed. It is now leading the company's line and is oversold for 3 years.

Farm and Industrial Machinery: Here, the use of functional color will supplant the present trend to using color for appearance or sales appeal. Color will highlight danger areas and flag hazards; it will abet ease of operation and both simplify and encourage maintenance. Strong, intense color on farm machinery enables the farmer to keep track of his equipment in the fields and to determine readily whether it is idle or in operation.

Office Machines: With the trend towards attractive, modern color firmly established, there will be an increased concentration on functional color—on such present problems as increasing keyboard legibility and differentiating various manual operations. Then, too, there will be an increasing trend toward matching color ensembles. Telephones, staplers, typewriters, will be in matching colors on each desk top. Ultimately, even desk tops may be more colorful.

Trains: As in aircraft, the value of high-visibility color in trains is obvious. In the future more and more trains will be dressed in high-visibility colors. At the same time new and more durable finishes will be used to build company personality—both on rolling stock and on other railroad equipment and structures.

One of eight colors developed by the author for telephone handsets to add accent and color appeal to homes and offices. The colored handsets offer the user individuality and prestige. The colors can serve a functional role if one color is assigned for direct lines and one or more other colors for switchboard extensions. The new line of colors — ivory, beige, green, blue, red, yellow, brown and gray—posed some production problems. The plastic handpiece on previous black telephones did not readily take to color. Western Electric had to use new materials and modify manufacturing processes before matched colored parts for the new instruments could be turned out.

enough colors to meet any conceivable demand? There is a strong argument for the shotgun approach to choosing and manufacturing profitable colors, and it finds a parallel in- the restaurant business. When Howard Johnson went into this business he was in competition with experts, experts offering three flavors of ice cream: vanilla, chocolate and strawberry. Vanilla was the big seller. Despite the advice of people who pointed out that obviously the public was buying vanilla because it wanted vanilla, Howard Johnson offered his customers 26 flavors of ice cream. His sales were enormous but his sales of vanilla were small; clearly the public was buying vanilla because it had no other choice. The Howard Johnson method of offering the public whatever it might want turned into effective profit. Today, Howard Johnson restaurants feature 28 flavors!

On the other hand a tile company tried a similar technique with tile color, featuring at one time a line of 39 tile colors. Analysis showed that 10 per cent of these colors were constituting 79 per cent of the company's total sales. From this study a line of twelve colors was selected that covered 95 per cent of the company's sales leaving competing tile companies with inventories glutted with needless and profitless colors.

Integrating Color with Design

Color must be integrated in the planning and development stages of a design. The design must be planned to accept color gracefully and logically. This tight connection of color and design has some specific effects.

First, color should fit logically into a section or sections of a machine or product. It is fussy and contrived-looking, and certainly never necessary, to have color areas ending on a flat field with no logical line of demarcation. Where, for appearance or functional reasons, the designer wants to use color areas that do not follow the logical sections of the machine, he should create logical areas. A good example of this technique turns up in the automobile industry where chrome strips create logical color areas on the multicolored car.

Second, material choice may have a determining effect on what colors can be employed in a product. Different materials take color differently. Plastics are the best example; it is often difficult, for instance, to achieve a color match between a pair of different plastic materials. The Bell telephone colors were originally developed for a handset with a phenolic handpiece and a butyrate base. Bell found that the phenolic—albeit durable, inexpensive and easy to mold—did not take well to color. The company then switched to an all-butyrate phone, only to find that this new handpiece material required different molding techniques and the eventual solution of some new acoustic difficulties. The company had an equally knotty problem integrating its rubber phone cords and metal dials into the eight new, basic color standards for the phones.

The moral of the story is that getting the color wanted can often be expensive and sometimes impossible. This is another item of color preplanning that the designer should consider before he carries his appearance design concept too far.

There should be pleasing visual units between form and color. The designer's attitude should be to give a product fewer, yet proper, colors and color relationships—colors that will be especially compatible with the maximum range of the product's end-use surroundings.

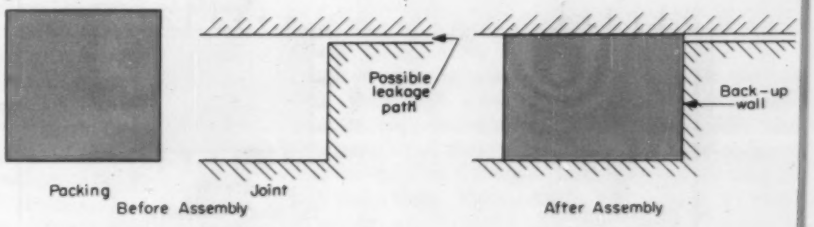


Fig. 1—The interference seal assembly, with seal ring fitted to undersize space to close leakage path.

O-Rings and Interference Seals

for Static Applications

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Interference seals, such as the familiar O-ring, are widely employed for static sealing in nearly all pressure ranges. However, the mechanics of such seals are relatively little known. This article presents a complete mathematical analysis of interference seals, gives recommended design formulas, and describes a recently developed application.

SINCE its conception about 20 years ago, the O-ring has become one of the most widely known and used sealing devices ever employed. Its simplicity and dependability, especially as a static seal, make its continued use a virtual certainty. However, in spite of the wide acceptance of the O-ring as a hydraulic packing, the fundamental mechanics of its sealing action are not widely known. This article will examine the sealing mechanism of "interference" packings, a family which includes the O-ring.

The term "interference packing" is used here to describe a class of packings in which the sealing action is automatic and the initial seal is established by an interference fit between the packing and the surrounding parts of the joint to be sealed. These packings are almost invariably in the form of rubber rings of various proportions and shapes of cross section. Although such cross sectional forms as round, U-shaped, and rectangular have been used successfully, it has been demonstrated[1] that all shapes behave in a similar manner when fluid pressure is applied to the sealed joint.

To explain the principle of operation of the interference packing, assume that a joint is to be sealed by a ring of, say, rectangular section. The ring is fitted between the parts to be sealed so that the space between parts is somewhat narrower than the section of the packing ring. Fig. 1 is a cross-section view of such an installation, showing the joint and the packing before and after assembly.

Because of the interference fit between the packing and the two lateral surfaces of the joint after assembly, there is a residual pressure, P_o, Fig. 2*a*, on the lateral surfaces of the packing. This pressure is sufficient to provide intimate contact between the packing and the joint surfaces, thus closing the possible leakage path. A seal is thereby formed which will apparently prevent leakage, at least if the fluid pressure, P_f, applied to the joint is less than the initial sealing pressure P_o.

If the packing is made from a pliable grade of

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[1]References are tabulated at end of article.

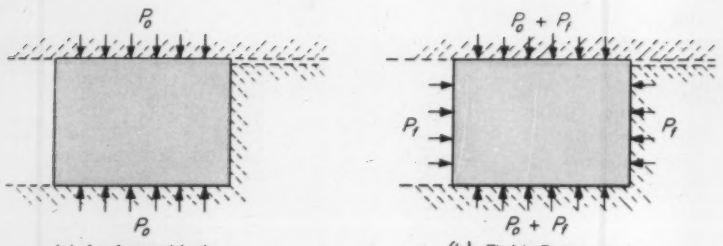

Fig. 2—Action of a rubber interference seal under fluid pressure.

solid rubber, it may be shown[2] that when fluid pressure is applied to the upstream end of the packing, the packing moves over against the supporting backup wall. A pressure is then produced on the lateral surfaces which is the sum of the applied fluid pressure, P_f, and the initial sealing pressure P_o, Fig. 2*b*. Hence, whatever the applied fluid pressure may be, a sealing pressure is maintained on the lateral surfaces of the packing which exceeds the fluid pressure by the margin P_o. The action of the seal is therefore completely automatic once an initial seal is established. This action continues until a pressure is reached sufficient to cause extrusion of the packing through the small clearance spaces of the joint, destroying the original geometry of the seal.

Analysis of Sealing Action

The automatic action just described is due to the mechanical properties of the rubber packing: (1) it has a relatively high bulk modulus of elasticity, (2) it has a relatively low modulus of elasticity in simple compression, and (3) it can support statically a difference of principal stresses. That these properties insure the automatic action of an interference seal may be shown from the analysis of an elastic solid under a triaxial stress system.

In Fig. 3, an elementary cube of an elastic material is stressed on its three pairs of opposite faces by the unit compressive stresses† σ_x, σ_y, and σ_z. Assume that E represents the modulus of elasticity in simple compression for the material and μ its Poisson's ratio. Unit strains in the three directions are denoted by ϵ_x, ϵ_y, and ϵ_z, and may be evaluated as:

$$\epsilon_x = \frac{\sigma_x}{E} - \frac{\mu}{E}(\sigma_y + \sigma_z) \tag{1.1}$$

$$\epsilon_y = \frac{\sigma_y}{E} - \frac{\mu}{E}(\sigma_x + \sigma_z) \tag{1.2}$$

$$\epsilon_z = \frac{\sigma_z}{E} - \frac{\mu}{E}(\sigma_x + \sigma_y) \tag{1.3}$$

If four faces of the cube are prevented from expanding (as by rigid constraining walls) when a pressure is applied to the other pair of faces, then a pressure will be induced on the restrained faces. If the pressure applied to the two free faces is σ_x, then the induced pressure $\sigma_y = \sigma_z$ on the restrained faces may be determined from Equation 1.2 by substituting $\epsilon_y = 0$ and $\sigma_y = \sigma_z$. Then,

$$0 = \frac{\sigma_y}{E} - \frac{\mu}{E}(\sigma_x + \sigma_z)$$

from which

$$\sigma_y = \sigma_z = \sigma_x \left(\frac{\mu}{1-\mu} \right) \tag{2}$$

From Equation 2, it is seen that the amount of the induced pressure is dependent only upon μ, the Poisson's ratio for the material, and σ_x, the applied pressure.

If incremental pressures $d\sigma_x = d\sigma_y = d\sigma_z$ are applied to an initially unstressed cube L inches on a side, the volume of the cube will be reduced by an amount dV. Since the initial volume, V, equals L^3, then

$$dV = 3L^2 dL = 3L^3 \frac{dL}{L} = 3V \frac{dL}{L}$$

and

$$\frac{dV}{V} = 3\frac{dL}{L} \tag{3}$$

From Equation 1.1, substituting $d\sigma_x = d\sigma_y = d\sigma_z$, and noting that, for a homogeneous material, $\epsilon_x = \epsilon_y = \epsilon_z = dL/L$,

$$\frac{dL}{L} = \frac{d\sigma_x}{E} - \frac{\mu}{E}(d\sigma_x + d\sigma_x)$$

or

$$\frac{dL}{L} = \frac{d\sigma_x}{E}(1 - 2\mu) \tag{4}$$

Combining Equations 3 and 4,

$$\frac{dV}{V} = 3\frac{d\sigma_x}{E}(1 - 2\mu)$$

or

$$\frac{d\sigma_x}{dV/V} = \frac{E}{3(1-2\mu)} \tag{5}$$

Equation 5 defines the bulk modulus of elasticity, $d\sigma/(dV/V)$, in terms of the elastic properties E and μ.

†For convenience, compressive stresses and strains are here considered positive in sign.

Rubber is often considered to be incompressible.[3] Actually, its compressibility is about the same as that of water,[4] which, at standard atmospheric conditions, has a bulk modulus of elasticity[5] of about 320,000 psi. The modulus of elasticity in compression depends upon the rubber compound and ranges approximately from 180 to 510 psi for "soft" rubbers (40-70 durometer) at room temperatures.[6]

By substituting these values into Equation 5, it is seen that, for "soft" rubbers, $\mu = 0.499$, or 0.50 for practical purposes. Upon substitution of $\mu = 0.50$, Equation 2 becomes $\sigma_x = \sigma_y = \sigma_z$, and it is apparent that rubber, when confined, transmits pressure in much the same manner as a fluid. This fact, of course, is widely known and has been for many years exploited in the hydraulic forming process for sheet metal parts.

As contrasted with a fluid, however, rubber can support statically a difference in principal stresses. Referring again to Fig. 3, assume that a residual stress system exists on a rubber cube in which $\sigma_{xo} = 0$ and σ_{yo} and σ_{zo} have values which are the result of the cube's having been initially deformed in the Y and Z directions, as by an interference fit within restraining walls. If a pressure σ_x is then applied, a hydrostatic stress system is superimposed on the residual system, and the pressures in the Y and Z directions become $\sigma_y = \sigma_{yo} + \sigma_x$ and $\sigma_z = \sigma_{zo} + \sigma_x$. Hence, the action of the interference seal, as illustrated in Fig. 2, is entirely dependent upon the fact that Poisson's ratio for pliable grades of rubber is very nearly 0.50.

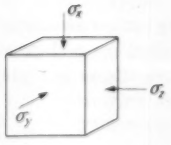

Fig. 3 — The triaxial stress system of the seal.

Other soft packing materials such as leather, felt, graphited asbestos, and rubber cork compounds are considerably more compressible than rubber, so the Poisson's ratio (if such a property may be defined for these materials) is appreciably less than 0.50. For cork, in fact, μ can be taken equal to zero.[7] With the relationships given by Equation 2, it is evident that such materials would not be suitable for interference-type packings, since the fluid pressure can overcome the sealing pressure, thereby causing a leak. Substances such as gelatin, however, have been used for purposes of investigation and behave in the same manner as rubber.[8]

A New Practical Application

The principles described here were used by the Applied Physics Laboratory for the development of underwater equipment. The new seal is essentially a thick rubber washer fitted with diametral interference between the cable and the surrounding housing. Because the sealing action is entirely automatic, no tightening or other operation is required after assembly as is the case with conventional compression packings, Fig. 4. The sealing pressure of the new packing depends upon the pressure applied by the liquid, whereas in the compression packing the sealing pressure depends upon the tightening of the packing nut. Insufficient tightening will allow leakage through seal; excess tightening may cause collapse of the cable.

In the new packing gland, Fig. 5, the sealing action is automatic and independent of the skill and judgment of the mechanic who installs it. The packing, which is an interference fit with both the cable and the housing, is held in place by a metal washer and a retaining ring.

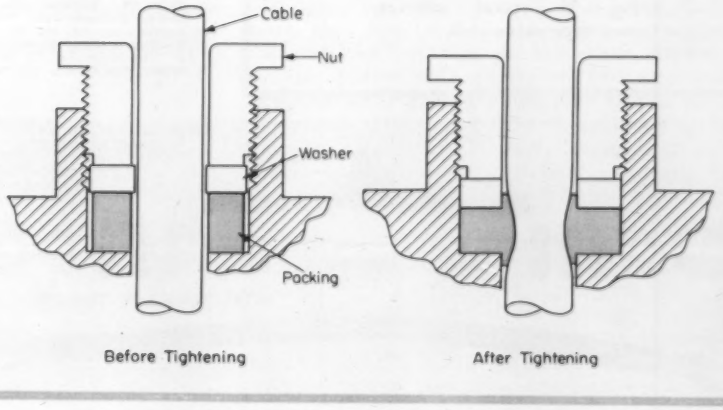

Fig. 4—Typical compression type cable gland.

The metal washer also keeps the cable centered against sidewise forces. With this arrangement, it is impossible to damage the cable by overtightening the packing gland, since there is no provision (or need) for tightening.

In some instances, the packing is made up of two or more rubber washers pressed into place one after another, with the air between washers being bled out along a small wire placed against the housing wall during assembly and later removed.

Design Proportions

In the design of such a gland, the packing and housing space must be proportioned to render the seal effective, yet not too difficult to assemble. The packing must be of adequate size to allow for an appreciable reduction in cable diameter when the packing is acted upon by fluid pressure. Satisfactory results have been obtained using packing with an inside diameter of about $0.7D$, an outside diameter of $2.5D$, and a length of $1.5D$, where D is the diameter of the cable to be sealed. The housing bore is made about 1/64 to 1/32-in. smaller than the outside diameter of the packing. Proper allowance must be made for the increase in length of the packing when assembled. This is most simply computed on the assumption that the cable does not compress during assembly and that the volume of the packing remains constant. At the present time, packings are molded from neoprene of about 40 durometer hardness.

For applications in which the seal is to be used at depths greater than a few hundred feet or for long periods of time, downstream extrusion of the packing may be minimized by providing a close fit of the cable with the hole at the bottom of the housing, or by incorporating a harder rubber washer on the downstream end of the gland, if multiple washers are used. Tests have also shown that in a packing of sufficient length (at least one cable diameter) considerable downstream extrusion of the packing can occur without impairing the effectiveness of the gland.

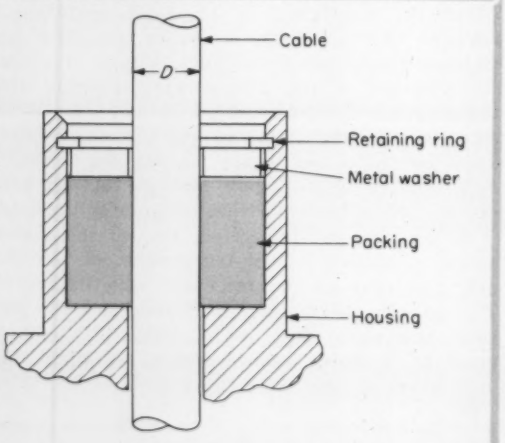

Fig. 5—Typical interference type cable seal.

Test Method

For over two years, interference cable seals have been used successfully at depths up to 600 ft for periods of several months of continuous immersion. In Fig. 6 is shown a pressure test unit with a section from a typical cable. The unit consists of a cylinder with a packing gland at each end. The cable passes entirely through the unit. In testing, the cylinder is filled with water and subjected to internal pressure. When testing interference glands, the threaded nuts are not tightened at assembly and only support the brass backup washer. In one test, the unit was subjected to 5300 psi before the cable failed by collapse due to fracture of several conductors inside the jacket. No leakage occurred until cable failure.

This work supported by the Bureau of Ordnance, U. S. Navy, under contract NOrd 12937.

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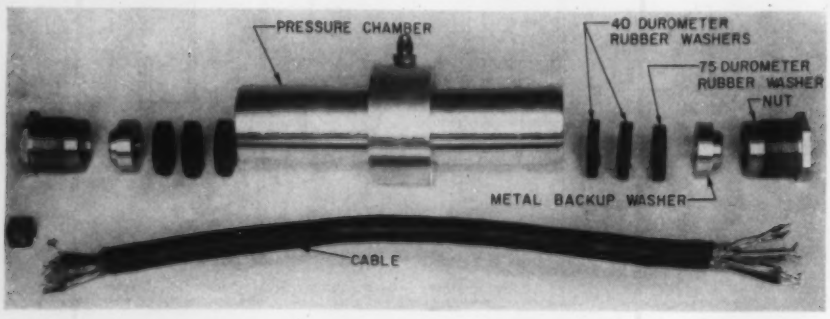

Fig. 6—Exploded view of cable seal test unit. This arrangement withstood 5000 psi without leaking. The nuts act as support only and are not tightened.

Significance of material properties in

Design for Fatigue Loading

Part 2

Generalized Failure Theories
Design for Static Stresses
Design for Static Stress Concentration

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FAILURE of statically stressed materials—by exceeding yield or ultimate strengths—has been defined by a number of widely known theories. Such conventional failure definitions, outlined in the section *Conventional Failure Theories*, are not based on plastic stress-strain relations. They have a number of important limitations:

1. For a given case, the theory recommended for use depends both upon the material selected and whether yield or ultimate stress is used to define failure.
2. The Mohr theory (internal friction theory) defines failure only approximately where materials have different strengths in tension and compression.
3. The conventional theories do not apply where uniaxial strengths in different directions are not equal.

In this article, generalized thories of failure (or strength) are developed as a step toward eliminating these limitations.

Generalized Failure Theories

For an element subjected to triaxial stresses, Fig. 5*b* (Part 1), it is assumed that failure is a function of the second stress invariant.[18] Then, for isotropic materials without directional properties and with the same strength in simple tension and compression, failure for combined stresses is defined by

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 = 2\,\sigma_t^2 \qquad (25)$$

where σ_t is the failure strength (yield or ultimate) in simple tension.

It can be shown that Equation 25 is identical with the relation representing failure by the distortion energy criterion (Equation 2*a*), providing σ_t represents yield strength in simple tension. If failure is assumed to be a function of octahedral shear stress, Equation 25 is also obtained.[7] It is found, furthermore, that results of this equation correspond to the statistical average of the shear stresses on all slip planes of a polycrystalline aggregate.[19] Equation 25 is also obtained (for biaxial stresses of opposite sign) if failure is assumed to be a function of internal friction. In such an event, failure shear stress τ must be a quadratic function of normal stress σ_n on the critical plane, or,

$$\tau^2 = a\,\sigma_t^2 - b\,\sigma_n^2$$

Note also that Equation 25 represents the expression for the effective or significant stress used in formulating the stress-strain relations in the plastic range according to the simple deformation theory (Ref. 1, 7, 8, 9).

Although the foregoing observations in them-

[18]References are tabulated at end of article.

selves provide strong support to the selection of Equation 25 as a basis of failure, the significant supporting consideration is that most available test data for ductile and isotropic materials validate its results (Ref. 1, 7, 15).

Equation 25 requires (1) that material have equal strengths in simple tension and compression, and (2) that each of these strengths have the same value in all directions. For materials in which these conditions are not met, that is, where the material is anisotropic, the equation can be modified as indicated in the following section.

Strength Theory for Anisotropic Materials: For cases where materials have different tensile strengths, σ_t, in different directions (anisotropic) Equation 25 can be modified to read:

$$[K_a(\sigma_1 - \sigma_2)]^2 + [K_b(\sigma_2 - \sigma_3)]^2 + [K_c(\sigma_3 - \sigma_1)]^2 = 2\sigma^2 \quad (26)$$

For two-dimensional stresses, $\sigma_3 = 0$, and Equation 26 becomes

$$a^2\sigma_1^2 + b^2\sigma_1\sigma_2 + c^2\sigma_2^2 = 1 \quad (27)$$

where

$$a^2 = \frac{K_a^2 + K_c^2}{2\sigma^2}$$

$$b^2 = \frac{K_a^2}{\sigma^2}$$

$$c^2 = \frac{K_a^2 + K_b^2}{2\sigma^2}$$

The values of a, b and c, Equation 27, can be obtained from three simple strength properties of the material. Various possible strengths might be considered. In this development, a, b and c are found from the simple tensile strengths in the σ_1 and σ_2 directions, and from the simple torsional strengths. Conditions $\sigma_1 = \sigma_{t1}$ for $\sigma_2 = 0$, $\sigma_2 = \sigma_{t2}$ for $\sigma_1 = 0$, and $\sigma_1 = -\sigma_2 = \tau_s$ for $\sigma_1 = -\sigma_2$, permit values of a, b and c to be determined. When

Conventional Failure Theories

Yield Strength: Various yield strength theories for isotropic ductile materials have been proposed (Ref. 1, 7, 14, 15). Referring to the element in Fig. 5*b* (Part 1), yielding occurs for a value of the stress σ_1 which depends upon the values and signs of the other stresses σ_2 and σ_3. Theories of failure have been developed which define the value of maximum principal stress σ_1 at yielding in terms of other principal stresses and yield stress in simple tension. If σ_{yp} is the yield strength in simple tension, the two main theories used for defining failure for ductile materials are the *maximum shear stress* and *distortion energy or Von Mises-Hencky theories.* Equations defining these theories are expressed for the case of triaxial stresses.

MAXIMUM SHEAR STRESS THEORY: One of the equations following governs failure by this theory. The applicable equation depends upon the relative magnitudes and signs of the stresses:

$$\sigma_1 - \sigma_2 = \pm\sigma_{yp} \quad (1a)$$

$$\sigma_2 - \sigma_3 = \pm\sigma_{yp} \quad (1b)$$

$$\sigma_3 - \sigma_1 = \pm\sigma_{yp} \quad (1c)$$

The maximum shear theory is used by many designers for ductile materials. It is specified in many company codes and codes such as the *ANC Code for Design of Aircraft Members.*

DISTORTION ENERGY THEORY: Basing failure on the concept that the elastic distortion energy is the stress function defining failure by yielding, the failure relation is

$$\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - \sigma_1\sigma_2 - \sigma_2\sigma_3 - \sigma_3\sigma_1 = \sigma_{yp}^2 \quad (2a)$$

A graphical representation of both the maximum shear and distortion energy theories for biaxial stresses, Fig. 8, is obtained by substituting $\sigma_3 = 0$ in Equations 1*a*, 1*b*, 1*c* and 2*a*. Most biaxial stress test results on ductile metals show that the distortion energy theory is in best agreement with these test results.[1,15] As shown in Fig. 8, the maximum shear theory is therefore

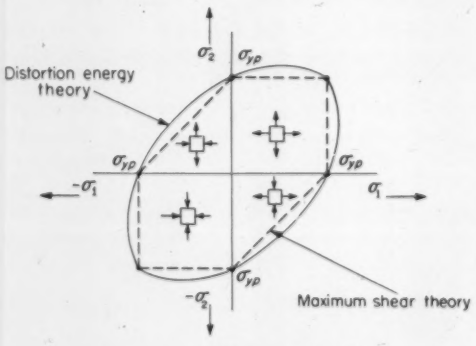

Fig. 8 — Yield-strength failure values in ductile materials.

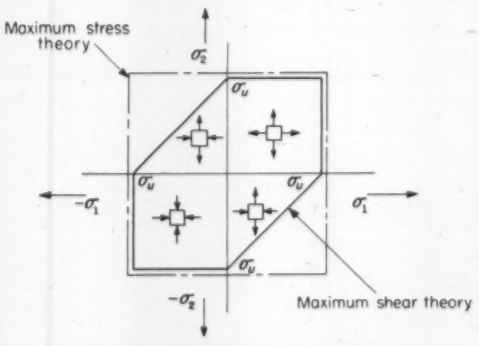

Fig. 9 — Ultimate-strength failure values in ductile materials.

these are substituted in Equation 27, the failure relation becomes

$$\sigma_1^2 + \left[1 + \left(\frac{\sigma_{t1}}{\sigma_{t2}} \right)^2 - \left(\frac{\sigma_{t1}}{\tau_s} \right)^2 \right] (\sigma_1 \sigma_2) + \left(\frac{\sigma_{t1}}{\sigma_{t2}} \right)^2 \left(\sigma_2^2 \right) = \sigma_{t1}^2 \qquad (28)$$

Equation 28 reduces to Equation 25 (distortion energy theory) when $\sigma_3 = 0$, $\sigma_{t1} = \sigma_{t2} = \sigma_t$, and $\tau_s = \sigma_{t1}/\sqrt{3}$. A plot of Equation 28 for $\sigma_{t1}/\sigma_{t2} = 0.75$ and $\sigma_{t1}/\tau_s = 1.5$ is shown in Fig. 11. For purposes of comparison, the special case representing the distortion energy theory is also shown. In this case, $\sigma_{t1}/\sigma_{t2} = 1$ and $\sigma_{t1}/\tau_s = 1.73$. Fig. 11 shows that the method of formulation of this theory requires that the simple tension and compression strengths in a given direction be equal. It should also be noted that a modification of Equation 28 is necessary when the directions of the principal stresses do not coincide with the directions for which the strengths σ_{t1} and σ_{t2} are known.

A New Generalized Theory: For materials with different strengths in tension and compression, and for materials with simple tensile and compressive strengths that vary in different directions, a more general relation than that given by Equation 26 is needed. For this purpose, Equation 26 is replaced by

$$(\sigma_1 - a')^2 + (\sigma_2 - b')^2 + (\sigma_3 - c')^2 + q[(\sigma_1 - a')(\sigma_2 - b') + (\sigma_2 - b')(\sigma_3 - c') + (\sigma_3 - c')(\sigma_1 - a')] = \sigma^2 \qquad (29)$$

Evaluation of a', b' and c' depends on the specific application. For example, for biaxial stresses, if simple tensile strengths in the σ_1 and σ_2 directions are σ_{t1} and σ_{t2}, the simple compressive strength in the σ_1 direction is σ_c, and the strength for $\sigma_1 =$

on the safe side of the distortion energy and the test results.

Ultimate Strength: Various theories of failure for ultimate strength in isotropic materials have been proposed (Ref. 1, 7, 14, 15). It is usually recommended that for ductile materials the *maximum shear theory* be used, while for brittle materials the *maximum stress theory* is often used.

MAXIMUM SHEAR THEORY: Assuming triaxial stresses, equations that result from the theory of maximum shear are:

$$\sigma_1 - \sigma_2 = \pm \sigma_u \qquad (3a)$$

$$\sigma_2 - \sigma_3 = \pm \sigma_u \qquad (3b)$$

$$\sigma_3 - \sigma_1 = \pm \sigma_u \qquad (3c)$$

MAXIMUM STRESS THEORY: With triaxial stresses, equations derivable from the maximum stress theory are:

$$\sigma_1 = \pm \sigma_u \qquad (4a)$$

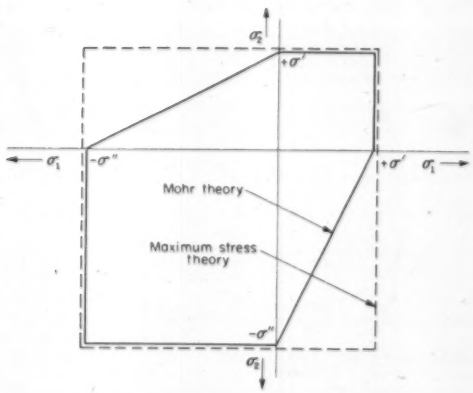

Fig. 10—Failure stresses in brittle materials.

$$\sigma_2 = \pm \sigma_u \qquad (4b)$$

$$\sigma_3 = \pm \sigma_u \qquad (4c)$$

In these equations, σ_u is nominal or true ultimate stress in simple tension or compression. For two-dimensional stresses, $\sigma_3 = 0$. Results of the equations are plotted in Fig. 9.

Theories for fracture can be expressed with the aid of these equations by replacing σ_u with σ_f, the nominal or true fracture strength in simple tension or compression.

Different Strengths in Tension and Compression: Strengths in simple tension and compression are not equal for some materials. Two of the main theories that have been recommended for such materials are the *internal friction theory* (sometimes referred to as the Mohr theory) or the *maximum stress theory*.[16,17] These theories are plotted in Fig. 10 for two-dimensional stresses.

INTERNAL FRICTION THEORY: Assuming biaxial stresses, failure equations are:

$$\sigma_1 = \sigma_2 = \sigma' \qquad (5a)$$

$$\sigma_1 = \sigma_2 = -\sigma'' \qquad (5b)$$

$$\sigma_2 - \left(\frac{\sigma''}{\sigma'} \right) \sigma_1 = -\sigma'' \qquad (5c)$$

$$\sigma_1 - \left(\frac{\sigma''}{\sigma'} \right) \sigma_2 = -\sigma'' \qquad (5d)$$

where σ' is yield, ultimate or fracture strength in simple tension, and σ'' is yield, ultimate or fracture strength in simple compression.

MAXIMUM STRESS THEORY: Equations derived on the basis of this theory are:

$$\sigma_1 = \sigma_2 = \sigma' \qquad (6a)$$

$$\sigma_1 = \sigma_2 = -\sigma'' \qquad (6b)$$

It has been recommended [16,17] that the *internal friction theory* be used for most materials since the few available test results indicate that this theory is conservative.

$-\sigma_2$ is τ_s, it can be shown that Equation 29 becomes

$$\sigma_1^2 + K_1\sigma_1\sigma_2 + \sigma_2^2 + K_2\sigma_1 + K_3\sigma_2 = K_4 \quad (30)$$

or

$$\sigma_1^2 + \left\{ 2 - \frac{1}{\tau_s^2}\left[\sigma_{c1}\sigma_{t1} - \tau_s\left(\sigma_{c1} - \sigma_{t1} - \frac{\sigma_{c1}\sigma_{t1}}{\sigma_{t2}} + \sigma_{t2} \right) \right] \right\} \sigma_1\sigma_2 + \sigma_2^2 + (\sigma_{c1} - \sigma_{t1})\sigma_1 + \left(\frac{\sigma_{c1}\sigma_{t1}}{\sigma_{t2}} - \sigma_{t2} \right)\sigma_2 = \sigma_{c1}\sigma_{t1} \quad (31)$$

For an isotropic material $\sigma_{c1} = \sigma_{t1} = \sigma_{t2} = \sigma_t$, and Equation 31 reduces to

$$\sigma_1^2 - \left[2 - \left(\frac{\sigma_t}{\tau_s} \right)^2 \right] \sigma_1\sigma_2 + \sigma_2^2 = \sigma_t^2 \quad (32)$$

If the shear strength τ_s is taken as $\sigma_t/\sqrt{3}$, Equation 32 reduces to the equation for the distortion energy theory. For the case where $\sigma_{t2} = 0.8\ \sigma_{t1}$, $\sigma_{c1} = 1.20\ \sigma_{t1}$, and $\tau_s = 0.8\ \sigma_{t1}$, results are plotted in Fig. 12. With these substitutions Equation 31 gives

$$x^2 - 0.5\,xy + y^2 + 0.2\,x + 0.7\,y = 1.2 \quad (33)$$

where $x = \sigma_1/\sigma_{t1}$ and $y = \sigma_2/\sigma_{t2}$.

The generalized theories described in this article may be adapted to both ductile and brittle materials. This is made possible by the flexibility introduced by the experimental constant τ_s in both Equations 28 and 31.

Example 1—Combined Shaft Loading

Problem is to determine required diameter d of a circular shaft under combined twisting moment M_t and bending moment M; the working strength relation, Equation 34, is the basis of the calculations.

For a shaft subjected to both torsion and bending, the critical element is the outer fiber where the stress components have maximum values:

$$\sigma_x = \frac{Mr}{I} = \frac{32\,M}{\pi d^3}$$

$$\tau_{xy} = \frac{M_t r}{I_p} = \frac{16\,M_t}{\pi d^3}$$

Principal stresses σ_1 and σ_2 produced by stress components σ_x and τ_{xy} are

$$\sigma_1 = \frac{\sigma_x}{2} - \sqrt{\frac{\sigma_x^2}{4} + \tau_{xy}^2}$$

and

$$\sigma_2 = \frac{\sigma_x}{2} - \sqrt{\frac{\sigma_x^2}{4} + \tau_{xy}^2}$$

With values of σ_1 and σ_2 substituted in Equation 34, the working stress relation becomes

$$0.75\,\sigma_x^2 + 0.5\,(\sigma_x - \sigma_{w1})\sqrt{\frac{\sigma_x^2}{4} + \tau_{xy}^2} + 1.5\,\tau_{xy}^2 + 0.45\,\sigma_{w1}\sigma_x = 1.2\,\sigma_{w1}^2$$

This equation, when combined with the equations for σ_x and τ_{xy}, gives d, the required shaft diameter.

Design for Static Stresses

Theories of failure which give the strength of an element subjected to combined stresses have been defined here. Failure relations have been in all cases expressed in terms of strengths in simple tension and compression. Working stress relations corresponding to these failure relations can be obtained by using the equations that have been developed, provided failure strengths in simple tension, compression and shear are replaced by allowable values. Working stress equations for combined stresses are formulated in various codes.[16-17] By the generalized theory, Equation 33, the working stress relation becomes

$$\sigma_1^2 - 0.5\,\sigma_1\sigma_2 + \sigma_2^2 + 0.2\,\sigma_1\sigma_{w1} + 0.7\,\sigma_2\sigma_{w1} = 1.2\,\sigma_{w1}^2 \quad (34)$$

where σ_{w1} = the working tensile stress for the σ_1 direction. Use of this equation to determine the dimensions of a member often requires principal stresses to be determined from the stress components. The method is illustrated in Example 1.

In some design problems, the critical element cannot be selected by inspection. In such cases the stress components and the principal stresses at a point in the member are expressed in terms of the loads, dimensions and the co-ordinates of the point. The expressions for the principal

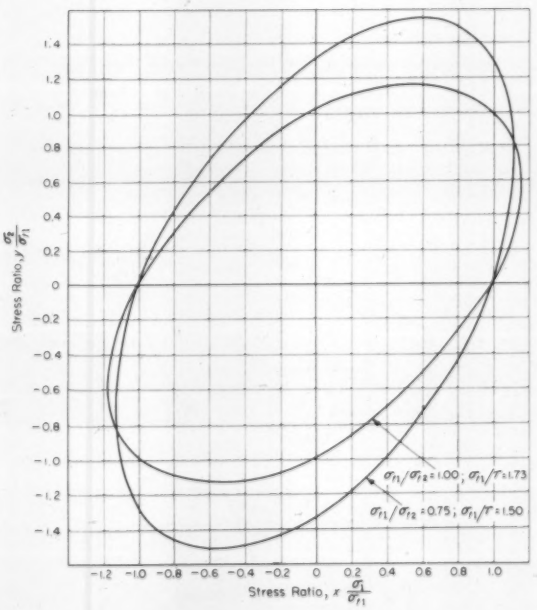

Fig. 11—Failure in nonisotropic materials with directional properties.

stresses are then substituted in a working stress equation, such as Equation 34. To determine the location of the critical element, the left-hand side of Equation 34 is considered as an equivalent tensile stress. Differentiating with respect to the variable co-ordinate and equating to zero gives an equation which defines the position of the critical element. With the position of the critical element known, Equation 34 is then used to find the required dimension of the element. Examples of such calculations are given in Ref. 15.

Design for Static Stress Concentration

It is well known that in areas of stress concentration, such as at fillets, grooves, holes and keyways, state of stress is neither simple tension nor compression, but a state of combined stress. This is true not only for members under complex loadings, but also for members subjected to axial tension—e.g., bars with circumferential grooves.

For certain members, loadings, and types of discontinuities, theoretical stress-concentration factors based on the theory of elasticity have been obtained.[20] In other cases, stress-concentration factors have been experimentally obtained by use of photoelastic and strain-gate techniques. These stress-concentration factors are nominally determined for the maximum normal stress.

Allowance for stress concentration in design has often been made by simply correcting the maximum normal stress for stress concentration. This procedure is based on the maximum stress theory. A more rational procedure is to consider the combined stress effect—that is, to apply the correct theory of failure to the particular problem. For example, in the cylindrical bar with a circumferential groove subjected to axial tension let σ_1 be the axial stress and σ_2 be the circumferential stress at the edge of the groove. Then by the Von Mises or distortion energy theory, strength is defined by

$$\sigma_1^2 - \sigma_1 \sigma_2 + \sigma_2^2 = \sigma_t^2 \qquad (35)$$

where σ_t = yield strength in simple tension.

If σ_n is the nominal axial stress (the axial yield load divided by the net area), then Equation 35 can be expressed as

$$\left(\frac{\sigma_1}{\sigma_n}\right)\sqrt{1 - c + c^2} = \frac{\sigma_t}{\sigma_n} \qquad (36)$$

or

$$k_t\sqrt{1 - c + c^2} = K_t \qquad (37)$$

where $k_t = \sigma_1/\sigma_n$ is the *stress-concentration factor*, while K_t is the *combined stress-concentration factor*. The factor k_t is the usual factor applied in design while the factor K_t considers both stress concentration and the combined stress effect. Values of both k_t and K_t (as calculated by Equation 37) have been determined for variety of members and types of stress concentration, Reference 21; results are plotted there to facilitate selection of combined stress-concentration factors.

Stress concentration as treated by the foregoing methods does not include effects of plastic flow. In some cases, designers must deal with loads that produce plastic flow of the material. It is known that at points of stress concentration, loading in the plastic range produces a redistribution of stress and a reduction in stress-concentration factors. Theoretical determination of stress-concentration factors in the plastic range presents a difficult problem. Some attempts have been made to determine the plastic stress-concentration factors experimentally.[22]

Considerable research on the behavior of materials under static combined stresses is needed. Experimental evidence supporting the generalized theories of failure proposed here is available only for certain stress combinations and for a few materials. Limited results are available for cases of triaxial stresses. Ideally, design studies should consider both plastic and elastic stress-strain relations.

In the next article of this series, discussion turns to simple fatigue stresses and their relationship to material properties.

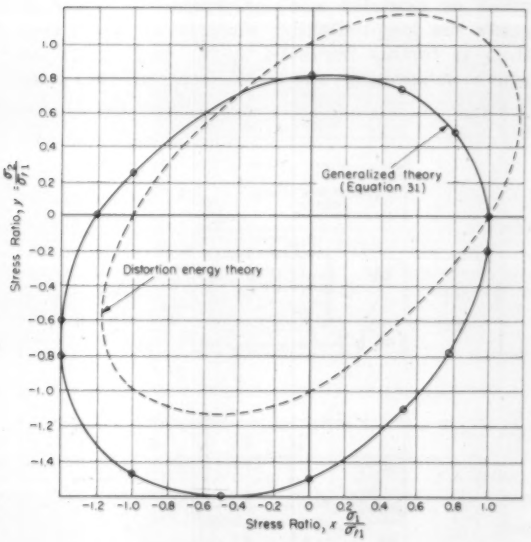

Fig. 12—Generalized theory of failure for nonisotropic materials.

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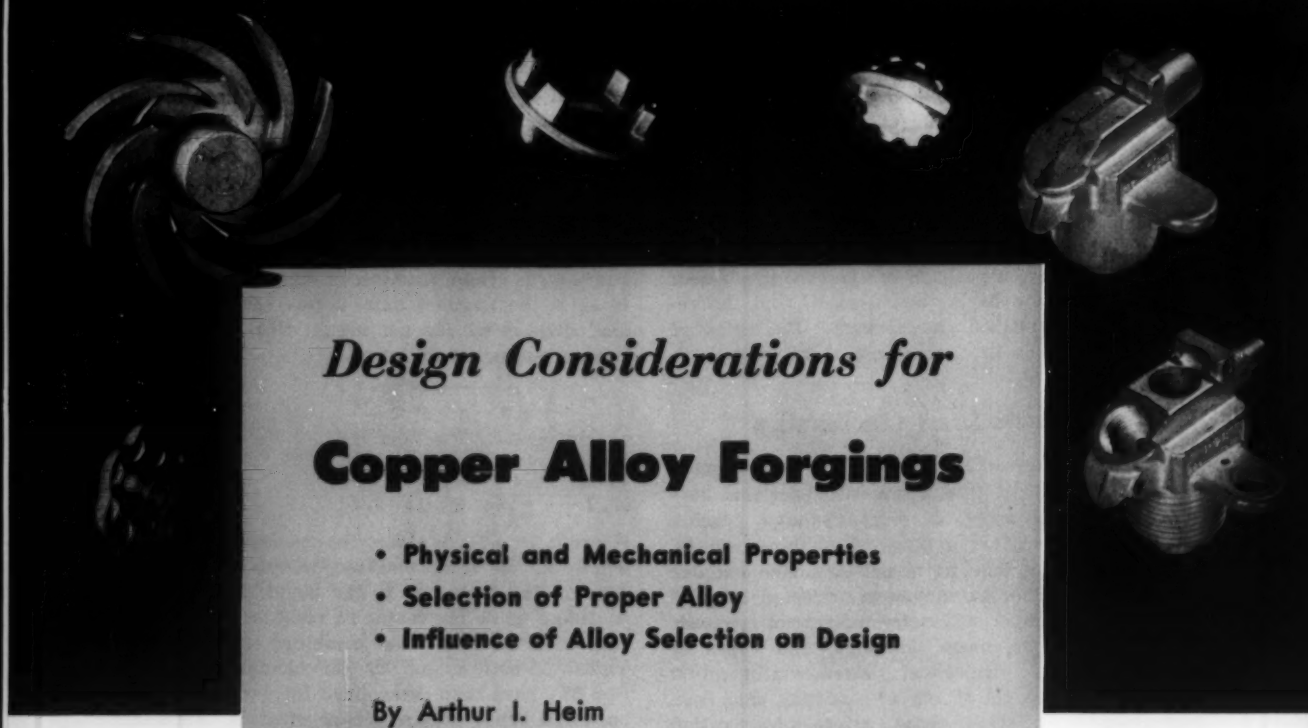

Design Considerations for

Copper Alloy Forgings

- **Physical and Mechanical Properties**
- **Selection of Proper Alloy**
- **Influence of Alloy Selection on Design**

By Arthur I. Heim

Research Engineer
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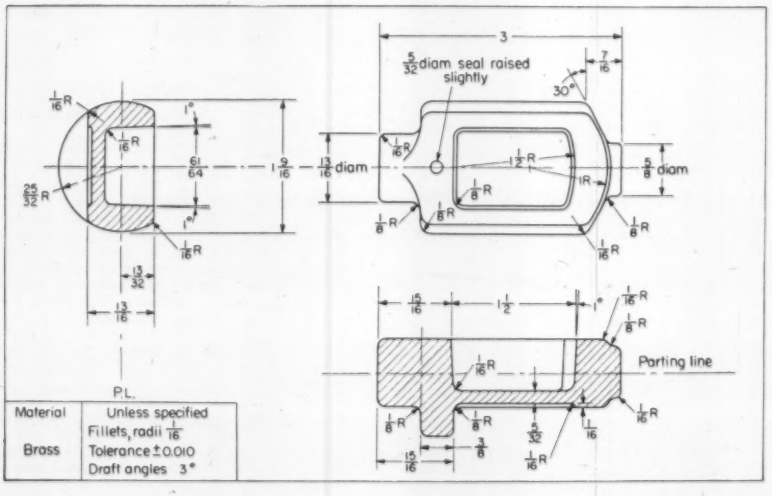
FORGING is the plastic deformation of metal at an elevated temperature into a predetermined size or shape using compressive forces exerted through a die by a hammer, press or upsetting machine. In the copper industry the term "forging" usually means work performed in closed-die or impression-die presses. Drop forging and open-hammer forging have comparatively small application in copper alloy forging work.

Copper-alloy forgings present characteristics which are extremely useful for a wide variety of products. Forgings have a uniform, dense grain structure resulting in high strength at low unit weight. In many cases forgings are made from rolled or extruded stock in which the fibers already run longitudinally. Material cut from such stock is further improved by the forging process where compacting and refinement of the grain



Yoke forging of brass.

occurs. Plastic metal flow under the pressure of forging causes the grain direction to conform to the general contours of the piece, parallel to the direction in which the highest stresses occur. This second working improves the homogeneity of the metallic structure, producing light, strong sections. Where machining is required, forgings are advantageous due to the uniform nature of the material, allowing good tool life.

Forging dies cost more initially than pattern equipment for sand castings and unless the quantity is substantial, forgings may not be warranted. Copper-base alloys do, however, provide good die life because of the relatively low temperatures involved.

In general, hot-forging of copper-base alloys permits runs of 12,000 to 40,000 pieces depending on the part being produced and die design. A simple closed die can turn out 30,000 to 40,000 pieces before tooling must be renewed. If a punch is surrounded by metal, as in certain extrusion dies, a run of 12,000 to 15,000 forgings can be expected. In one typical example, forging a booster fuse in a three-part die, the bottom die was serviceable for 40,000 pieces, the surrounding die for 30,000 and the punch for 15,000. Normally, as copper content increases, tool life decreases.

When multiple-cavity dies can be used, the number of forgings produced from one die obviously is increased proportionately. A die which lasts, say, for 25,000 press operations can produce 100,000 parts if a four-cavity die is used.

The original slug is generally cut from rod and formed to the final required shape in one stroke of the press. Occasionally, when severe or intricate deformation is required, it is necessary to substitute an extruded shape cut to length for the slug customarily cut from rod. In such instances the extruded shape is designed to partially conform the metal in advance to the final shape.

Forging results in parts with a consistent dimensional accuracy and very close tolerances. This will often result in eliminating machining light finishing cuts on parts and surfaces and reducing material waste. Forgings up to 2 lb leave the die within 0.008 to 0.015-in. of size, with a smooth textured surface. The exact tolerances which can be expected will depend upon the particular alloy selected and the specific method of forging decided upon. Table 1 indicates the commercial tolerances for hot-pressed copper-base forging alloys, depending on the method of forging being used. For forgings over 2 lb, the producer of the forging should be consulted.

Advantages of this dimensional accuracy are evident in trouble-free use of jigs, fixtures, and holding devices for secondary operations. The uniformity of copper alloy forgings makes them ideally suited for machining on high-speed automatic chucking machines or automated produc-

Valve body forging of brass. This part contains intricate internal contours with an asymmetrical design.

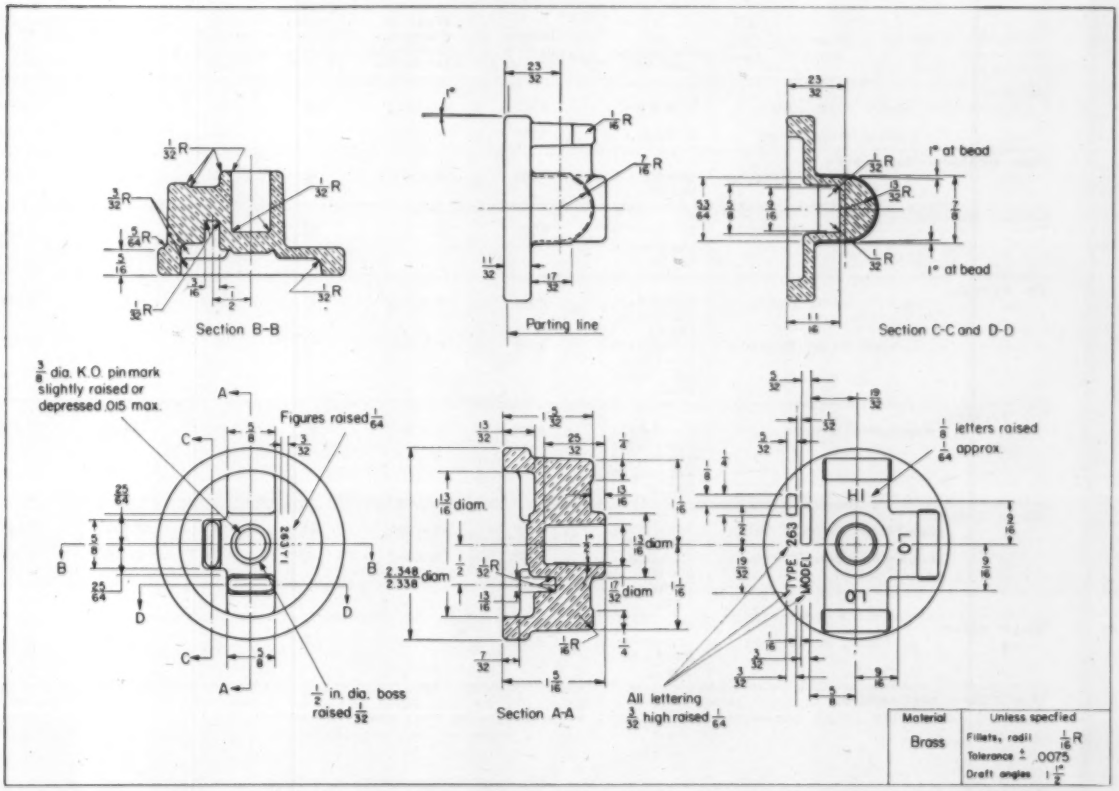
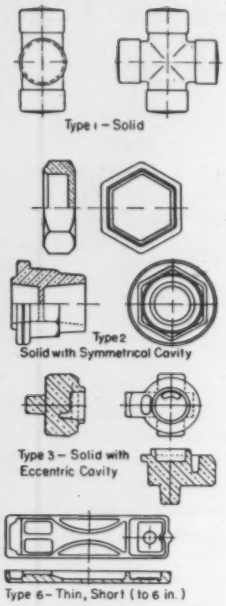
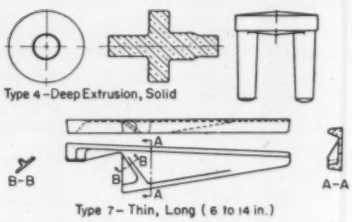


Table 1—Commercial Dimensional Tolerances of Forgings*

	Copper Aluminum-Silicon Bronze	Muntz Metal Forging Brass Naval Brass Leaded Naval Brass Manganese Bronze	High-Silicon Bronze	Nickel-Silver 45-10
Type 1 and 2	0.010	0.008	0.012	0.008
Type 3	0.012	0.008	0.012	0.008
Type 4, 5, 6 and 8	0.012	0.010	0.014	0.010
Type 7	0.015	0.015	0.020	0.015
Draft angles, one inside or outside, 1 to 5 degrees	½-degree	½-degree	½-degree	½-degree
Machining allowance per surface	1/32	1/32	1/32	1/32
Flatness: maximum deviation per inch	0.005	0.005	0.005	0.005
Concentricity: TIR	0.030	0.020	0.030	0.030
Nominal web thickness	3/32 ± 1/32	1/16 ± 1/32	3/32 ± 1/32	1/16 ± 1/32
Nominal fillet and radius	3/16 ± 1/32	1/32 ± 1/32	1/16 ± 1/32	1/32 ± 1/32
Approximate flash thickness	1/32	1/32	1/32	1/32

*For forgings up to 2 lbs. Except where specified, all values are inches.





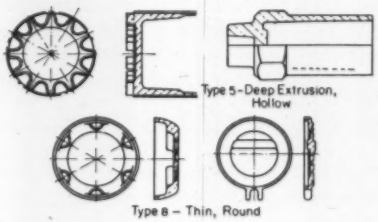


Table 2—Characteristics

(Average values)

	Composition (per cent)	Physical Properties: Density at 68 F (lb/cu in.)	Physical Properties: Coeff. of Thermal Expansion (per deg F)	Physical Properties: Thermal Conductivity (Btu/sq ft/ft/hr/deg F at 68 F)	Physical Properties: Electrical Conductivity at 68 F (per cent IACS)	Mechanical Properties: Tensile* Strength (psi)	Mechanical Properties: Yield Strength* ½% Elongation (psi)
Coppers							
Electrolytic Tough Pitch Copper	99.90 min Cu	0.321	98×10^{-7}	226	101	33,000	11,000
Deoxidized Copper	99.90 min Cu	0.323	98×10^{-7}	196	85	33,000	11,000
Plain Brasses—Nonleaded							
Muntz Metal	59.0-63.0 Cu Bal Zn	0.303	116×10^{-7}	71	28	58,000	21,000
Leaded Brasses							
Forging Brass	58.5-62.0 Cu 1.50-2.50 Pb Bal Zn	0.305	115×10^{-7}	69	27	58,000	23,000
Tin Brasses							
Naval Brass	59.0-62.0 Cu 0.50-1.00 Sn Bal Zn	0.304	118×10^{-7}	67	26	64,000	26,000
Leaded Naval Brass	59.0-62.0 Cu 0.50-1.00 Sn 1.25-2.25 Pb Bal Zn	0.305	118×10^{-7}	67	26	62,000	24,000
Tin Bronzes							
Manganese Bronze (A)	57.0-60.0 Cu 0.50-1.50 Sn 0.80-2.00 Fe 0.50 max Mn Bal Zn	0.302	118×10^{-7}	61	24	72,000	34,000
Silicon Bronzes							
High-Silicon Bronze (A)	94.8 min Cu 2.75-3.50 Si	0.308	100×10^{-7}	21	7	52,000	18,000
Aluminum-Silicon Bronze	(nominal) 91.0 Cu 7.0 Al 2.0 Si	0.278	92×10^{-7}	22	7	83,000	41,000
Nickel Silvers							
Nickel Silver 45-10	44.0-46.0 Cu 9.0-11.0 Ni Bal Zn	0.306	90×10^{-7}	27	10	83,000	36,000

*For 0.505-in. test section.
†Relative forgeability rating considers such variables as pressure, die wear and hot plasticity.

tion lines where handling accuracy is essential.

Where lettering or numerals are desired, either depressed or in relief, the clean-cut, sharply defined lines of the die provide clear, legible impressions difficult to obtain with other methods.

The natural appearance of as-forged copper-alloy forgings is smooth and attractive, so parts can be used as is, or they can be plated, lacquered, or enameled with a minimum of preparation.

When considering a copper alloy part for forging, the number of articles involved that can be made before renewal or replacement of the tooling is of vital importance. A sand cast or machined part should not be considered for forging until the design has been carefully reviewed. It is important that the item be specifically redesigned for forging. All of the simplification possible should be incorporated into the part. Factors such as weight reduction due to additional strength and improved grain structure, elimination of unnecessary machining, and a review of tolerances and draft angles must be considered. When comparing the forged design with the existing design the reduction of additional or secondary machining operations should be also considered.

When considering the specific material to be used the following factors should be reviewed:

1. Tensile strength
2. Yield strength
3. Forgeability
4. Hardness
5. Corrosion resistance
6. Conductivity (thermal and electrical)
7. Machinability
8. Joinability (soldering and brazing)
9. Weldability
10. Surface finish (natural or applied)

An analysis of the design for each of these factors indicates that commercially available alloys will meet the requirements with little or no trouble. The specific alloy to be used will depend upon the design requirements.

By forging, tensile strengths ranging from 30,000 to 85,000 psi can be achieved, depending upon the particular alloy selected. Table 2 gives the physical, mechanical, and fabricating properties of several alloys commonly forged by hot pressing. Other alloys are available and can be recommended by the mills for specialized problems which standard alloys cannot satisfy. The range of strengths available to the designer permits him to take other properties into consideration when selecting a material and still retain all of the inherent benefits of a copper-base material. Several

and Properties of Forgings

as hot pressed)

Mechanical Properties			Fabricating Properties								
Elongation* in 2 in. (per cent)	Rockwell Hardness	Relative Forgeability† (per cent)	Hot Working	Cold Working	Soft Soldering	Brazing§	Gas Welding§	Arc Welding§	Resistance Welding§	Machinability‡ (per cent)	Forging Temperature (average F)
45	37 F	65	E	E	E	G	P	F	P	20	1500
40	37 F	65	E	E	E	E	F	G	P	20	1500
48	46 B	90	E	F	E	G	G	F	F	40	1400
40	45 B	100	E	P	E	G	F	P	P	80	1400
40	55 B	90	E	F	E	G	G	F	F	30	1400
40	55 B	90	G	P	E	G	F	P	P	70	1400
33	69 B	80	E	P	E	G	G	F	G	30	1400
70	62 B	40	P	E	G	G	E	E	E	15	1600
35	77 B	75	F	P	F	F	F	F	F	55	1500
25	73 B	85	E	P	E	G	G	G	G	40	1400

§Values shown represent the general opinion of producers but are intended for comparative purposes only. E Excellent, G good, P Poor.

‡Machinability as related to free-cutting brass rod (100 per cent).

of the alloys offer outstanding specific properties, such as high electrical conductivity for current carrying members, or exceptional corrosion resistance for marine or outdoor service. Leaded alloys allow high-speed machining operations.

The inherent corrosion resistance of copper-base alloys to salt water, atmospheric gases, and many types of liquid and gaseous reagents make them particularly suitable for applications where long life under severe operating conditions is required. Corrosion resistance combined with a uniformly dense, homogeneous cross-section results in a dependable pressure-tight design. Copper-base alloy forgings are a natural answer in plumbing, refrigeration, chemical, and food processing industries where pressure tightness and corrosion resistance are necessary.

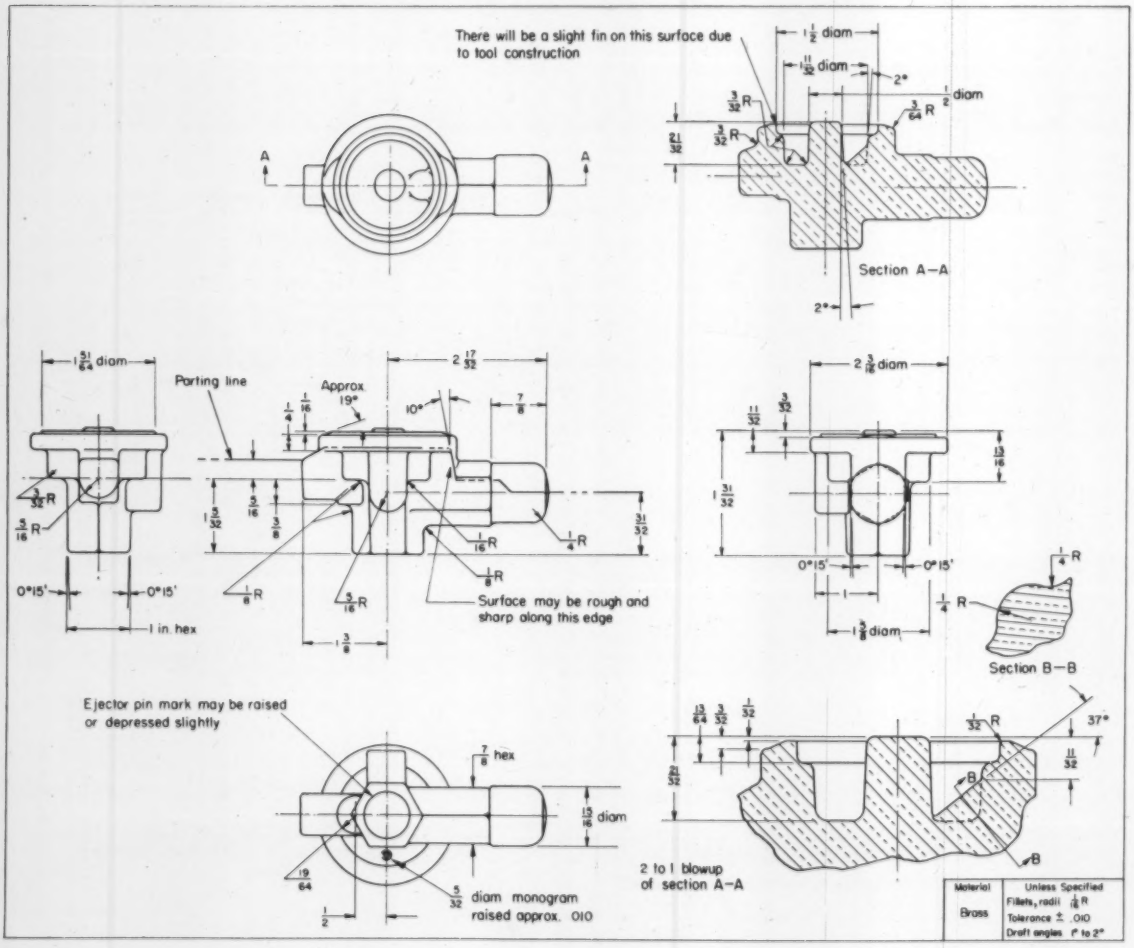
For example, the Chlorine Institute approves forged valves and fittings of Naval Brass to safely handle the highly reactive chlorine gas. Chemical manufacturers specify similar copper-base alloys for equipment subjected to the action of compounds which combine readily with other metals. Water works and sewage plants specify the use of silicon bronze parts in key locations for long, trouble-free operation. Refrigerator manufacturers make wide use of copper-base forged fittings because of their excellent corrosion resistance to moisture condensation and the action of the refrigerant, plus ease of machining. The ability to eliminate pressure testing and still obtain a dependable part which is not permeable to a refrigerant type gas is a highly important attribute of copper alloy forgings. In addition, chromium plated accessories such as handles and hinges retain their luster because the copper alloy underneath provides an excellent base for a lasting bond.

Copper-base alloy forgings should be considered where it is desirable or necessary to secure a dependable, pressure-tight part, superior surface finish, more compact design with equal or greater strength, ease of machining, improved production due to lowered scrap, or corrosion resistance.

ACKNOWLEDGEMENT

MACHINE DESIGN acknowledges with appreciation the co-operation of Scovill Mfg. Co. of Waterbury, Conn. for the part prints.

Expansion valve body of forging brass. Parting line follows contour of part at greatest width.


There will be a slight fin on this surface due to tool construction
Section A–A
Parting line
Approx 19°
10°
Surface may be rough and sharp along this edge
1 in. hex
Section B–B
Ejector pin mark may be raised or depressed slightly
7/8 hex
diam monogram raised approx. 010
2 to 1 blowup of section A–A
Material
Brass
Unless Specified
Fillets, radii 1/64 R
Tolerance ± .010
Draft angles 1° to 2°

How Profile Errors Affect

CAM DYNAMICS

. . . an analytical method for predicting influence of dimensional variations upon velocity and acceleration

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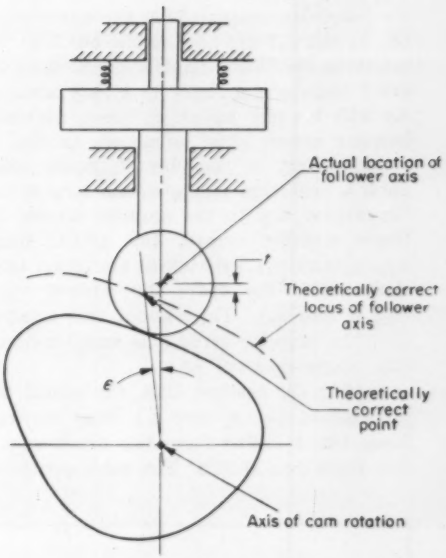

Fig. 1—Typical cam mechanism showing follower-displacement error and cam-angle error.

IT IS well-known that machining errors will exist on manufactured cams. Likewise, the reality of measuring errors must be considered when checking an actual cam for purposes of motion analysis. The method of finite differences[1,2] offers a means for predicting on paper the dynamic effects of such errors.

In the step-milling procedure for a master cam, two basic types of errors will exist. The first type results from inexact location of the cutter at positions corresponding to follower-body displacement values. Hence, this type of error will be termed follower-displacement error, and it will be denoted by $\pm t$. The second type of error is due to inexact location of the master cam at its prescribed angular positions. Hence, this type of error will be termed cam-angle error, and it will be denoted by $\pm \epsilon$.

Both follower-displacement error and cam-angle error are illustrated in Fig. 1. The worst possible dynamic effect will result if the errors are of the fluctuating, point-to-point variation type. General, overall errors of the same magnitude existing at each successive point and in the same direction have little dynamic effect. Equations 1 2, 6, 10, 11, and 12 are based on errors which cause the worst possible dynamic effects.

[1]References are tabulated at end of article.

As a matter of review, a previous article[1] showed that the acceleration fluctuation due to follower displacement errors is

$$a_t = \pm 144 \left(\frac{\omega}{\Delta\theta} \right)^2 t \qquad (1)$$

The previous article also showed that the velocity fluctuation due to such errors would be

$$v_t = \pm 12 \left(\frac{\omega}{\Delta\theta} \right) t \qquad (2)$$

The purpose of this article is to call attention to the dynamic effects of cam-angle error. From the following derivation and the accompanying example, it can be seen that very appreciable acceleration fluctuations can result from small angular-position errors, especially in the region of high velocity. Hence, this study will enable the designer to determine how precise the angular positioning should be in the step-milling process in order to obtain acceptably small acceleration fluctuations. Some setups might require a high-precision optical dividing head instead of a less-accurate, more-common type. On the other hand, it might be wasted effort to exercise too great care in angular positioning for other setups or regions.

In order to isolate the effects of follower-displacement errors and cam-angle errors, assume in

the following analysis that the *exact* displacements (s_1, s_2 and s_0) are obtainable, but that the angular locations for these displacements deviate from the exact angular positions by a very small angle, $\pm\epsilon$. As will become apparent later, assume that the angular errors exist as shown in Fig. 2, for the neighborhood of the point 0 under consideration. Such a condition will give the largest acceleration fluctuation due to the angular errors. Because of these angular errors, the actual displacements (y_1, y_2 and y_0) existing at the exact angular positions will differ from the desired displacements (s_1, s_2 and s_0). Throughout this analysis assume that the angular error ϵ, is small compared to the cam angle interval $\Delta\theta$.

In Fig. 2, assume that the exact desired displacements (s_1, s_2 and s_0) exist at angular locations which differ from the exact cam angles by the angle ϵ as shown. The basic acceleration equation from the theory of finite differences[1] shows that acceleration actually existing at point 0 will be

$$a_0 = 36 \left(\frac{\omega}{\Delta\theta}\right)^2 (y_1 + y_2 - 2\,y_0) \qquad (3)$$

But, using simple geometry in Fig. 2,

$$y_1 = s_1 + m\varepsilon$$
$$y_2 = s_2 + m\varepsilon$$
$$y_0 = s_0 - m\varepsilon$$

where m is the slope of the displacement curve in the neighborhood of point 0. Hence, Equation 3 becomes

$$a_0 = 36 \left(\frac{\omega}{\Delta\theta}\right)^2 (s_1 + s_2 - 2\,s_0 + 4\,m\varepsilon) \qquad (4)$$

However, if the exact angular locations had existed, then

$$a_0 = 36 \left(\frac{\omega}{\Delta\theta}\right)^2 (s_1 + s_2 - 2\,s_0) \qquad (5)$$

Therefore, the acceleration *deviation* due to the angular positioning errors would be Equation 4 minus Equation 5, or

$$a_\epsilon = \pm\, 36 \left(\frac{\omega}{\Delta\theta}\right)^2 4\,m\varepsilon$$

From Fig. 2,

$$m = \frac{s_2 - s_1}{2\,(\Delta\theta)}$$

Hence,

$$a_\epsilon = \pm\, 72 \left(\frac{\omega}{\Delta\theta}\right)^2 (s_2 - s_1)\,\frac{\varepsilon}{\Delta\theta} \qquad (6)$$

From Equation 6 it can be seen that the acceleration fluctuation due to angular positioning errors in cam manufacture is a function of the velocity factor, $(s_2 - s_1)$. Hence, from an acceleration fluctuation standpoint, it is more important to obtain very accurate cam-angle intervals at regions of high velocity than at points of low velocity. Such a statement is compatible with the obvious fact that the cam-angle interval need not be accurate at regions of zero-velocity dwells, since the cam surface is concentric with the cam axis at those regions.

As a further consideration, suppose that angular position errors, ϵ, exists as shown in Fig. 3 for the neighborhood of point 0. The exact displacement values (s_1, s_2 and s_0) would then exist as shown in Fig. 3. The actual displacements (z_1, z_2 and s_0) would exist as shown at the correct cam-angle intervals. Again, use of the theory of finite differences would show that the actual velocity at point 0 would be

$$v_0 = 3 \left(\frac{\omega}{\Delta\theta}\right) (z_2 - z_1) \qquad (7)$$

But from simple geometry,

$$z_1 = s_1 - m\varepsilon$$
$$z_2 = s_2 + m\varepsilon$$

where again m is the slope of the displacement curve in the neighborhood of point 0. Placing the

Nomenclature

- a_0 = Primary acceleration of the follower body at the point under consideration, in. per sec^2 for linear follower motion, or radians per sec^2 for angular follower body motion.
- a_t = Average *maximum deviation* of the follower body acceleration from the primary value due to t, units same as for a_0.
- a_ϵ = Maximum deviation of the follower body acceleration from the primary value due to cam angle errors, units same as for a_0.
- s = Displacement of the follower body from a fixed reference position, in. if the follower body undergoes linear motion, or radians if the follower body undergoes angular motion. Subscript 0 denotes the particular point under consideration, whereas subscripts 1 and 2 denote the two adjacent points.
- t = Follower displacement error, units same as for s. Maximum deviation of the follower body displacement from the desired value, due to machining or measuring errors.
- v_0 = Primary velocity of the follower body at the point under consideration, in. per sec for linear follower motion, or radians per sec for angular follower motion.
- v_t = Average *maximum deviation* of the follower body velocity from the primary value due to t, units same as for v_0.
- v_ϵ = Maximum deviation of the follower body velocity from the primary value due to cam angle errors, units same as for v_0.
- $\Delta\theta$ = Interval of cam rotation for which the follower body displacement values are given, degrees.
- ε = Cam angle error, degrees. Maximum angular deviation of a cam from any given angular position, due to rotational positioning error of the master cam in the step-milling procedure or due to rotational positioning error in the measuring of an existing cam.
- ω = Constant angular velocity of the cam, rpm.

relations for z in Equation 7 gives

$$v_0 = 3\left(\frac{\omega}{\Delta\theta}\right)(s_2 - s_1 + 2m\varepsilon) \tag{8}$$

However, if the exact angular positions had existed, then

$$v_0 = 3\left(\frac{\omega}{\Delta\theta}\right)(s_2 - s_1) \tag{9}$$

Therefore, the velocity *deviation* due to the cam-angle errors would be Equation 8 minus Equation 9 or

$$v_\epsilon = \pm 3\left(\frac{\omega}{\Delta\theta}\right) 2m\varepsilon$$

Thus,

$$v_\epsilon = \pm 3\left(\frac{\omega}{\Delta\theta}\right)\left(\frac{\varepsilon}{\Delta\theta}\right)(s_2 - s_1) \tag{10}$$

From Equation 10 it can be seen that the velocity fluctuation due to angular positioning errors in cam manufacture is again a function of the velocity factor, $(s_2 - s_1)$.

The total acceleration fluctuation due to both the follower-displacement errors and the cam-angle errors is merely the algebraic summation of the two. Hence, the actual secondary acceleration component is Equation 1 plus Equation 6. That is, total secondary acceleration is

$$a_t + a_\varepsilon = \pm 144\left(\frac{\omega}{\Delta\theta}\right)^2\left[t + \frac{\varepsilon}{2(\Delta\theta)}(s_2 - s_1)\right] \tag{11}$$

Likewise, the actual secondary velocity component is merely Equation 2 plus Equation 10:

$$v_t + v_\epsilon = \pm 12\left(\frac{\omega}{\Delta\theta}\right)\left[t + \frac{\varepsilon}{4(\Delta\theta)}(s_2 - s_1)\right] \tag{12}$$

Example: Suppose that a cam mechanism is to drive a follower body from one position to another during 34 degrees rotation of the cam. Assume that the cam will rotate with a constant angular velocity of 600 rpm and that the follower body is initially and finally in a state of rest. The mechanism is to be similar to the one shown in Fig. 1 and the total throw is to be 0.6910-in. Assume that the follower-body displacement values can be held to within a point-to-point variation of $\pm$0.0003-in. Also assume that the cam-angle values will be held to $\pm$1 minute in step milling the master cam.

A cam profile has already been developed for this problem using the theory of finite differences in a previous article.[2] The displacement values thus developed are tabulated in Table 1. The acceleration factors $(s_1 + s_2 - 2s_0)$ and the velocity factors $(s_2 - s_1)$ have also been calculated and they, too, are included in Table 1. The cam-angle interval $\Delta\theta$ is 1 degree.

For the problem under consideration, the maxi-

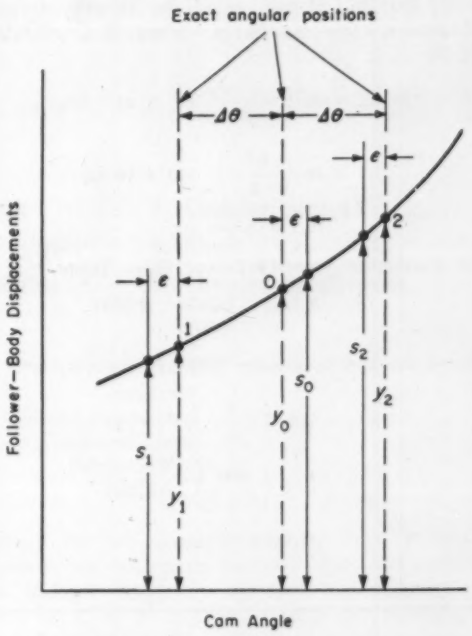

Fig. 2—Follower displacement vs. cam angle showing effect of cam-angle error. The s values are the desired displacements. The y-value displacements exist at the exact angular positions.

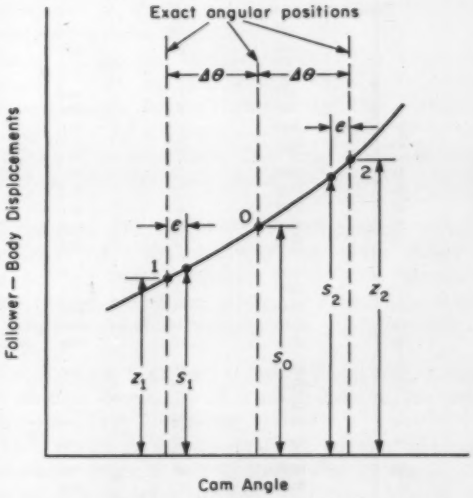

Fig. 3—Follower displacement vs. cam angle showing effect of cam-angle error. The s values are the desired displacements. The z-value displacements exist at the exact angular positions.

mum acceleration factor is $(s_1 + s_2 - 2s_0)_{max} = 31 \times 10^{-4}$ in. Hence, using the theory of finite differences, the maximum primary acceleration will be

$$(a_0)_{max} = 36 \left(\frac{\omega}{\Delta\theta} \right)^2 (s_1 + s_2 - 2s_0)_{max}$$

$$= 36 \left(\frac{600}{1} \right)^2 (31 \times 10^{-4})$$

$$= 40{,}100 \text{ in. per sec}^2$$

The maximum velocity factor from Table 1 is

$$(s_2 - s_1)_{max} = 0.3818 - 0.3092$$
$$= 0.0726$$

Therefore, the maximum primary velocity will be

$$(v_0)_{max} = 3 \left(\frac{\omega}{\Delta\theta} \right) (s_2 - s_1)_{max}$$

$$= 3 \left(\frac{600}{1} \right) (0.0726)$$

$$= 130.8 \text{ in. per sec}$$

Table 1—Example Data

Cam Angle (deg)	Follower Displacement (in. × 10^4)	Acceleration Factor (in. × 10^4) $(s_1 + s_2 - 2s_0)$	Velocity Factor (in. × 10^4) $(s_2 - s_1)$
− 1	0	0	0
0	0	+ 4	+ 4
1	4	16	24
2	24	22	62
3	66	27	111
4	135	28	166
5	232	31	225
6	360	29	285
7	517	31	345
8	705	30	406
9	923	27	463
10	1168	27	517
11	1440	23	567
12	1735	22	612
13	2052	17	651
14	2386	15	683
15	2735	8	706
16	3092	+ 6	720
17	3455	0	726
18	3818	− 6	720
19	4175	8	706
20	4524	15	683
21	4858	17	651
22	5175	22	612
23	5470	23	567
24	5742	27	517
25	5987	27	463
26	6205	30	406
27	6393	31	345
28	6550	29	285
29	6678	31	225
30	6775	28	166
31	6844	27	111
32	6886	22	62
33	6906	16	24
34	6910	− 4	+ 4
35	6910	0	0

From Equation 1 the acceleration deviation due to follower-displacement error in cam manufacture will be

$$a_t = \pm 144 \left(\frac{600}{1} \right)^2 (0.0003)$$
$$= \pm 15{,}600 \text{ in. per sec}^2$$

From Equation 2 the velocity deviation due to follower-displacement error in cam manufacture will be

$$v_t = \pm 12 \left(\frac{600}{1} \right) (0.0003)$$

$$= \pm 2.16 \text{ in. per sec}$$

Next, suppose that it is desired to calculate the maximum acceleration and velocity fluctuations which will result due to the cam-angle errors. In Equation 6 and 10 use $\omega = 600$ rpm, $\Delta\theta = 1$ degree, $(s_2 - s_1)_{max} = 0.0726$-in., and $\epsilon = 1$ min $= 0.01667$ degree.

From Equation 10 the velocity fluctuation will be

$$v_\epsilon = \pm 3 \left(\frac{600}{1} \right) \left(\frac{0.01667}{1} \right) (0.0726)$$

$$= \pm 2.18 \text{ in. per sec}$$

From Equation 6 the acceleration fluctuation due to cam-angle error will be

$$a_\epsilon = \pm 72 \left(\frac{600}{1} \right)^2 (0.0726) \left(\frac{0.01667}{1} \right)$$

$$= \pm 31{,}200 \text{ in. per sec}^2$$

Such an acceleration fluctuation would be very undesirable. Hence, it might pay to have a greater cam-angle accuracy in the step-milling procedure of the master cam. With an optical dividing head and great care, the cam-angle positions could be held within ±5 seconds, which would result in an acceleration fluctuation of only ±2620 in per sec^2 due to cam-angle error. This would be far more acceptable.

In order to obtain the total acceleration fluctuation (rightly termed the secondary component), due to both cam-angle errors and follower-displacement errors in the cam manufacture, it is permissible merely to add the two independent results algebraically. Hence, under the assumption that the follower displacements will be held to within ±0.0003-in. and that the cam-angle positions will be held to within± 1 minute, the total acceleration fluctuation will be ±15,600 + (±31,200) = ±46,800 in. per sec^2. On the other hand, if the cam-angle error is reduced to ±5 seconds, the total acceleration fluctuation due to both follower-displacement errors and cam-angle errors will be ±15,600 + (±2620) = ±18,220 in. per sec^2. This might be an entirely acceptable value, considering that the primary component of acceleration has a maximum value of 40,100 in. per sec^2.

REFERENCES

1. R. C. Johnson—"Cam Design," MACHINE DESIGN, Vol. 27, No. 11, November 1955, Pages 195-204.
2. R. C. Johnson—"Cam Profiles," MACHINE DESIGN, Vol. 28, No. 25, December 13, 1956, Pages 129-132.

Vibration Frequency Charts

1. Uniform beams
2. Variable-section beams
3. Continuous beams
4. Square plates
5. Rectangular plates
6. Cantilever plates
7. Circular plates
8. Rings
9. Circular membranes

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BEAMS and plates are common structural elements of mechanical design. It is often necessary to design these elements so that they have either a selected natural frequency or so that their natural frequencies are sufficiently far-removed from excitation frequencies to avoid resonance.

Tables and nomographs presented in this article provide a quick procedure for estimating natural frequencies of uniform and nonuniform beams, and uniform plates. These data enable the designer to assess the effect of changing the dimensions, type of support, and material of the structural element.

Data for the tables were obtained from readily available references. The theory underlying the data given for the natural frequencies of beams and plates assumes small deflections and neglects rotary inertia and shear effects. These restrictions must be kept in mind when determining frequencies from these data.

Method of Solution: The method is based on the use of a frequency constant defined as follows for the different types of structural elements:

Beams	$C = fL^2/k$
Square and rectangular plates	$C = fa^2/h$
Circular plates	$C = fr^2/h$

Symbols are defined for each case in Tables 1 to 10, appearing on the following pages, which give values of frequency constant C, or corresponding frequency function, for various mechanical structures and several modes of vibration. These tabulated values of C are based on the characteristic density and Young's modulus for steel.

The nomograph in Fig. 1 may be used with the proper frequency constant C and the characteristic dimensions to determine natural frequency directly. Nomographs in Figs. 2 and 3 present an alternate method for determining the natural frequency by first determining the value of L^2/k, a^2/h or r^2/h from the nomograph in Fig. 2 and then entering the nomograph in Fig. 3 with this item and the frequency constant. Figs. 1 to 3 are to be used with Tables 1 to 8 in which the values of the frequency constants are tabulated.

For materials other than steel, the material correction factor is obtained from the table in Fig. 4. With this factor, and the natural frequency, f_s, of a steel member of the same dimensions, the nomograph in Fig. 4 may then be used to determine the natural frequency.

Some of the less common mechanical structural members, such as membranes, have a frequency relation which is not defined by the foregoing nomographs. In such cases, numerical or slide rule calculation is necessary. The frequency constants for these members are given in Tables 9 and 10.

Example: Determine the fundamental natural frequency of a circular titanium plate, fixed at the center. Plate material is T1-75A titanium; plate radius, $r = 3$ in.; plate thickness, $h = 0.090$-in.; and estimated temperature of operation is 400 F.

From Table 7, $C/10^4 = 3.649$. From Fig. 1 then, the natural frequency of a steel plate of the same dimensions is $f_s = 370$ cps.

This result is also arrived at by the alternate procedure, Figs. 2 and 3. From Fig. 2, for $r = 3$ and $h = 0.09$, $r^2/h = 100$, and from Fig. 3, for a steel plate of the same dimensions, $f_s = 370$ cps.

Since plate material is titanium, final solution will be given by Fig. 4. From the table in Fig. 4, material correction factor for T1-75A titanium at 400 F is $K_m = 0.910$. From the nomograph then, for this value of K_m and $f_s = 370$ cps, frequency of the titanium plate is $f = 325$-350 cps.

This article is based on a paper entitled "Vibration Design Charts" presented at the ASME Annual Meeting in New York, November, 1956.

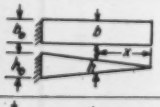
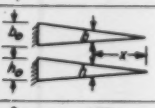
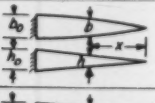
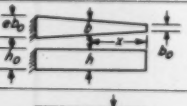
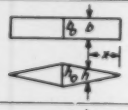
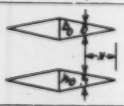
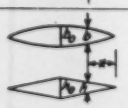
Table 1—Uniform Steel Beams

C = Frequency constant
f_s = Natural frequency, cps
$k = (I/A)^{1/2}$ = Radius of gyration, in.
L = Beam length, in.
M = Vibration mode number

Beam Structure	$C/10^4 = (f_s L^2/k)/10^4$				
	$M=1$	$M=2$	$M=3$	$M=4$	$M=5$
Clamped-Clamped / Free-Free	71.95	198.29	388.73	642.60	959.94
Clamped-Free	11.30	70.85	198.30	388.73	642.60
Clamped-Hinged / Free-Hinged	49.57	160.65	335.17	573.20	874.65
Clamped-Guided / Free-Guided	17.98	97.18	239.98	446.25	715.98
Hinged-Hinged / Guided-Guided	31.73	126.93	285.60	507.73	793.33
Hinged-Guided	7.93	71.40	198.33	388.73	642.60

Table 2—Variable-Section Steel Beams

C = Frequency constant
f_s = Natural frequency, cps
$k = (I/A)^{1/2}$ = Radius of gyration, in.
L = Beam length, in.
M = Vibration mode number

Beam Structure	b/b_0	h/h_0	$C/10^4 = (f_s L^2/k)/10^4$		
			$M=1$	$M=2$	$M=3$
	1	x/L	17.09	48.89	96.57
	x/L	x/L	26.08	68.08	123.64
	$(x/L)^{1/3}$	x/L	22.30	58.18	109.90
	$e^{x/L}$	1	15.23	77.78	206.07
	1	x/L	21.21* 35.05†	56.97	
	x/L	x/L	32.73* 49.50†	76.57	
	$(x/L)^{1/3}$	x/L	25.66* 42.02†	66.06	

*Symmetric. †Antisymmetric.

Table 3—Continuous Uniform Steel Beams

C = Frequency constant
f_s = Natural frequency, cps
$k = (I/A)^{1/2}$ = Radius of gyration, in.
L = Span length, in.
M = Vibration mode number
n = Number of spans

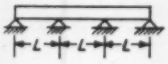
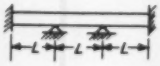
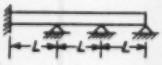
Beam Structure	n	$C/10^4 = (f_s L^2/k)/10^4$				
		$M=1$	$M=2$	$M=3$	$M=4$	$M=5$
Extreme Ends Simply Supported						
	1	31.73	126.94	285.61	507.76	793.37
	2	31.73	49.59	126.94	160.66	285.61
	3	31.73	40.52	59.56	126.94	143.98
	4	31.73	37.02	49.59	63.99	126.94
	5	31.73	34.99	44.19	55.29	66.72
	6	31.73	34.32	40.52	49.59	59.56
	7	31.73	33.67	38.40	45.70	53.63
	8	31.73	33.02	37.02	42.70	49.59
	9	31.73	33.02	35.66	40.52	46.46
	10	31.73	33.02	34.99	39.10	44.19
	11	31.73	32.37	34.32	37.70	41.97
	12	31.73	32.37	34.32	37.02	40.52
Extreme Ends Clamped						
	1	72.36	198.34	388.75	642.63	959.98
	2	49.59	72.36	160.66	198.34	335.20
	3	40.52	59.56	72.36	143.98	178.25
	4	37.02	49.59	63.99	72.36	137.30
	5	34.99	44.19	55.29	66.72	72.36
	6	34.32	40.52	49.59	59.56	67.65
	7	33.67	38.40	45.70	53.63	62.20
	8	33.02	37.02	42.70	49.59	56.98
	9	33.02	35.66	40.52	46.46	52.81
	10	33.02	34.99	39.10	44.19	49.59
	11	32.37	34.32	37.70	41.97	47.23
	12	32.37	34.32	37.02	40.52	44.94
Extreme Ends Clamped-Supported						
	1	49.59	160.66	335.2	573.21	874.69
	2	37.02	63.99	137.30	185.85	301.05
	3	34.32	49.59	67.65	132.07	160.66
	4	33.02	42.70	56.98	69.51	129.49
	5	33.02	39.10	49.59	61.31	70.45
	6	32.37	37.02	44.94	54.46	63.99
	7	32.37	35.66	41.97	49.59	57.84
	8	32.37	34.99	39.81	45.70	53.63
	9	31.73	34.32	38.40	43.44	49.59
	10	31.73	33.67	37.02	41.24	46.46
	11	31.73	33.67	36.33	39.81	44.19
	12	31.73	33.02	35.66	39.10	42.70

Table 4—Square Steel Plates

a = Plate side, in.
C = Frequency constant
f_s = Natural frequency, cps
h = Plate thickness, in.
M = Vibration mode number

Plate Structure*	$C/10^4 = (f_s a^2/h)/10^4$					
	$M=1$	$M=2$	$M=3$	$M=4$	$M=5$	$M=6$
	3.40	8.32	20.86	26.71	30.32	
	6.77	23.43	26.07	46.75	61.44	
	13.72	19.99	23.26	34.98	59.93	63.47
	19.20	48.00	76.82	96.01	124.82	163.25

Table 4 (Cont.)

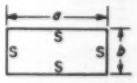
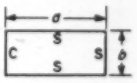
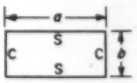
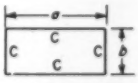
Plate Structure*	$C/10^4 = (f_s a^2/h)/10^4$					
	$M=1$	$M=2$	$M=3$	$M=4$	$M=5$	$M=6$
	23.01	50.28	57.06	83.79	97.58	110.13
	28.16	53.26	67.44	92.02	99.43	125.60
	35.01	71.42	105.36	128.03	128.71	160.72

*F = free, S = supported, C = clamped.

Table 5—Rectangular Steel Plates (First Vibration Mode)

$C/10^4 = (f_s a^2/h)/10^4$

a = Plate side, in.
C = Frequency constant
f_s = Natural frequency, cps
h = Plate thickness, in.

Plate Structure*	b/a	$C/10^4$	a/b	$C/10^4$
	1.0	19.20		
	1.5	13.87		
	2.0	12.00		
	2.5	11.14		
	3.0	10.67		
	∞	9.60		
	1.0	23.01	1.0	23.01
	1.5	18.39	1.5	15.15
	2.0	16.86	2.0	12.57
	2.5	16.18	2.5	11.43
	3.0	15.82	3.0	10.84
	∞	15.01	∞	9.60
	1.0	28.16	1.0	28.16
	1.5	24.37	1.5	16.90
	2.0	23.17	2.0	13.32
	2.5	22.64	2.5	11.80
	3.0	22.37	3.0	11.05
	∞	21.76	∞	9.60
	1.0	35.00		
	1.5	26.27		
	2.0	23.90		
	2.5	23.12		
	3.0	22.56		
	∞	21.76		

*F = free, S = supported, C = clamped.

Table 6—Cantilever Steel Plates

a = Plate side, in.
C = Frequency constant
f_s = Natural frequency, cps
h = Plate thickness, in.
M = Vibration mode number
θ = Skew angle, deg

Plate Structure*	$C/10^4 = (f_s a^2/h)/10^4$				
Rectangular Cantilever Plate					
a/b	$M=1$	$M=2$	$M=3$	$M=4$	$M=5$
½	3.41	5.23	21.36	9.98	24.18
1	3.40	8.32	20.86	26.71	30.32
2	3.38	14.52	21.02	91.92	47.39
5	3.36	33.79	20.94	548.60	103.03

Skewed Cantilever Plate		
θ	$M=1$	$M=2$
15	3.50	8.63
30	3.85	9.91
45	4.69	13.38

*F = free, C = clamped.

Table 7—Circular Steel Plates

C = Frequency constant
f_s = Natural frequency, cps
h = Plate thickness, in.
r = Plate radius, in.
m = Number of nodal circles
n = Number of nodal diameters

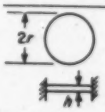
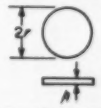
Plate Structure*	$C/10^4 = (f_s r^2/h)/10^4$			
n	$m=0$	$m=1$	$m=2$	$m=3$
 Circular Plate Clamped at Boundary				
0	9.936	38.713	86.516	
1	20.651			
2	33.906			
 Circular Plate With Free Boundary				
0		8.832	37.487	
1		19.970	58.255	
2	5.110	34.295		
3	11.902	51.491		
Circular Plate Clamped at Center				
....	3.649	20.349	59.053	116.490

Table 8—Steel Ring Vibrating In Its Own Plane

C = Frequency constant
f_s = Natural frequency, cps
h = Ring thickness, in.
n = Number of full waves around periphery
r = Mean ring radius, in.

Ring Structure	$C/10^4 = (f_s r^2/h)/10^4$				
	$n=2$	$n=3$	$n=4$	$n=5$	$n=6$
	2.51	7.10	13.6	22.2	32.2

Table 9—Circular Steel Membranes

C_f = Frequency function
f_s = Natural frequency, cps
h = Membrane thickness, in.
m = Number of nodal circles
n = Number of nodal diameters
s = Tension of periphery, lb/in.

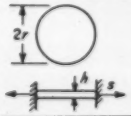
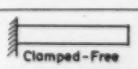
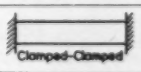
Membrance Structure	$C_f = f_s r/(s/h)^{1/2}$						
m	$n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$
	1	14.09	22.49	30.12	37.46	44.56	51.55
	2	32.41	41.22	49.44	57.30	64.94	72.22
	3	50.79	59.71	64.94	76.45	84.55	92.18
	4	69.28	78.09	86.90	95.12	103.34	111.56
	5	87.48	96.88	105.68	113.91	122.13	130.35
	6	106.27	115.08	123.89	132.69	140.91	149.13
	7	124.47	133.87	142.68	150.90	159.70	167.92
	8	143.26	152.07	160.88	169.68	178.49	186.71

Table 10—Longitudinal Vibration of Steel Beams

C_l = Frequency function
f_s = Natural frequency, cps
L = Beam length, in.
n = Number of halfwaves along beam length

Beam Structure	$C_l/10^4 = f_s L/10^4$					
	$n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$
 Clamped-Free	5.05	15.15	25.25	35.35	45.46	55.56
 Clamped-Clamped	10.10	20.20	30.30	40.41	50.51	

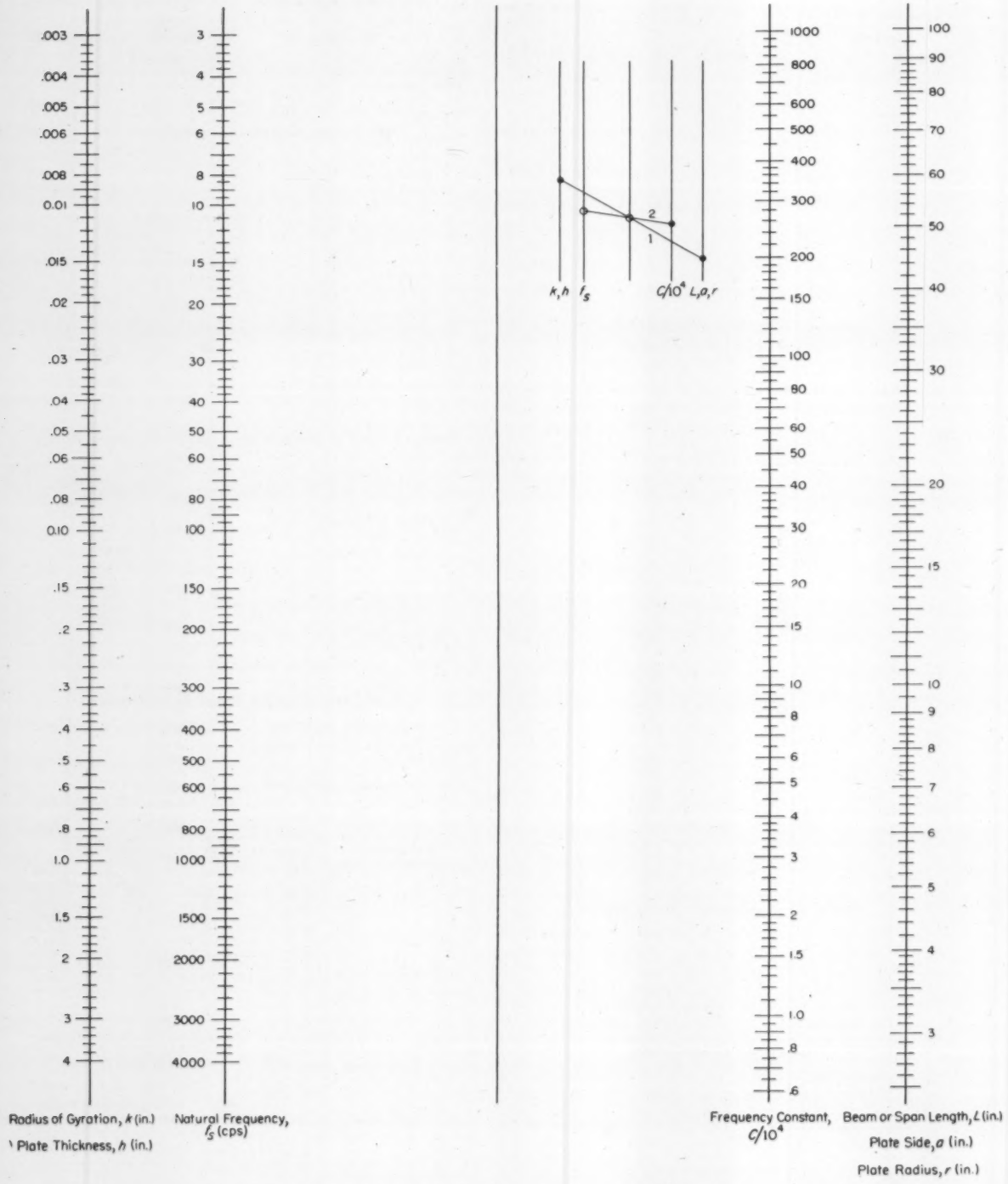


Fig. 1 — Nomograph for determination of natural frequency f_s from frequency constant C, in Tables 1 to 8.

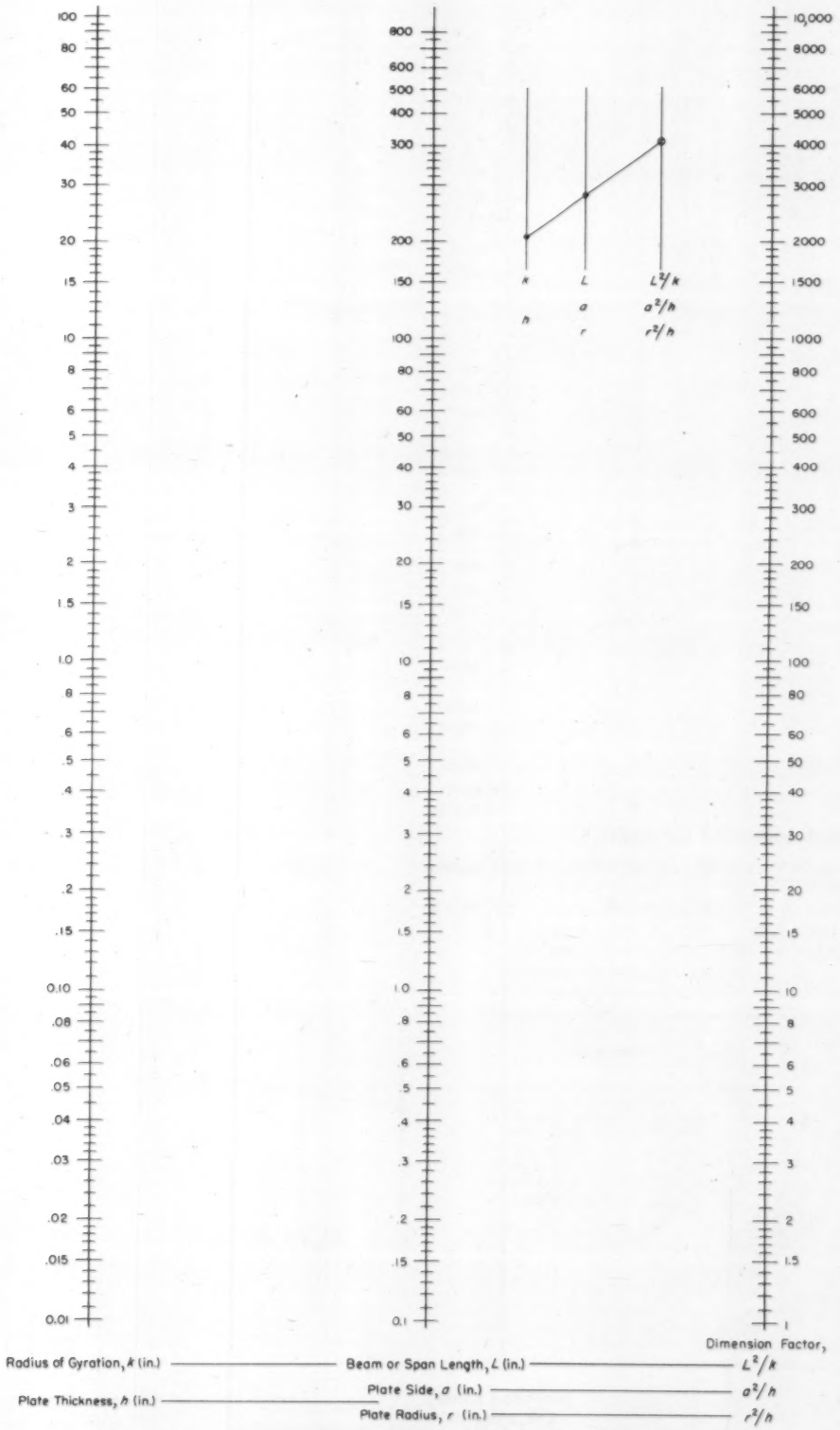


Fig. 2—Nomograph for determination of dimension factors, L^2/k, a^2/b and r^2/b in frequency constant equations of Tables 1 to 8.

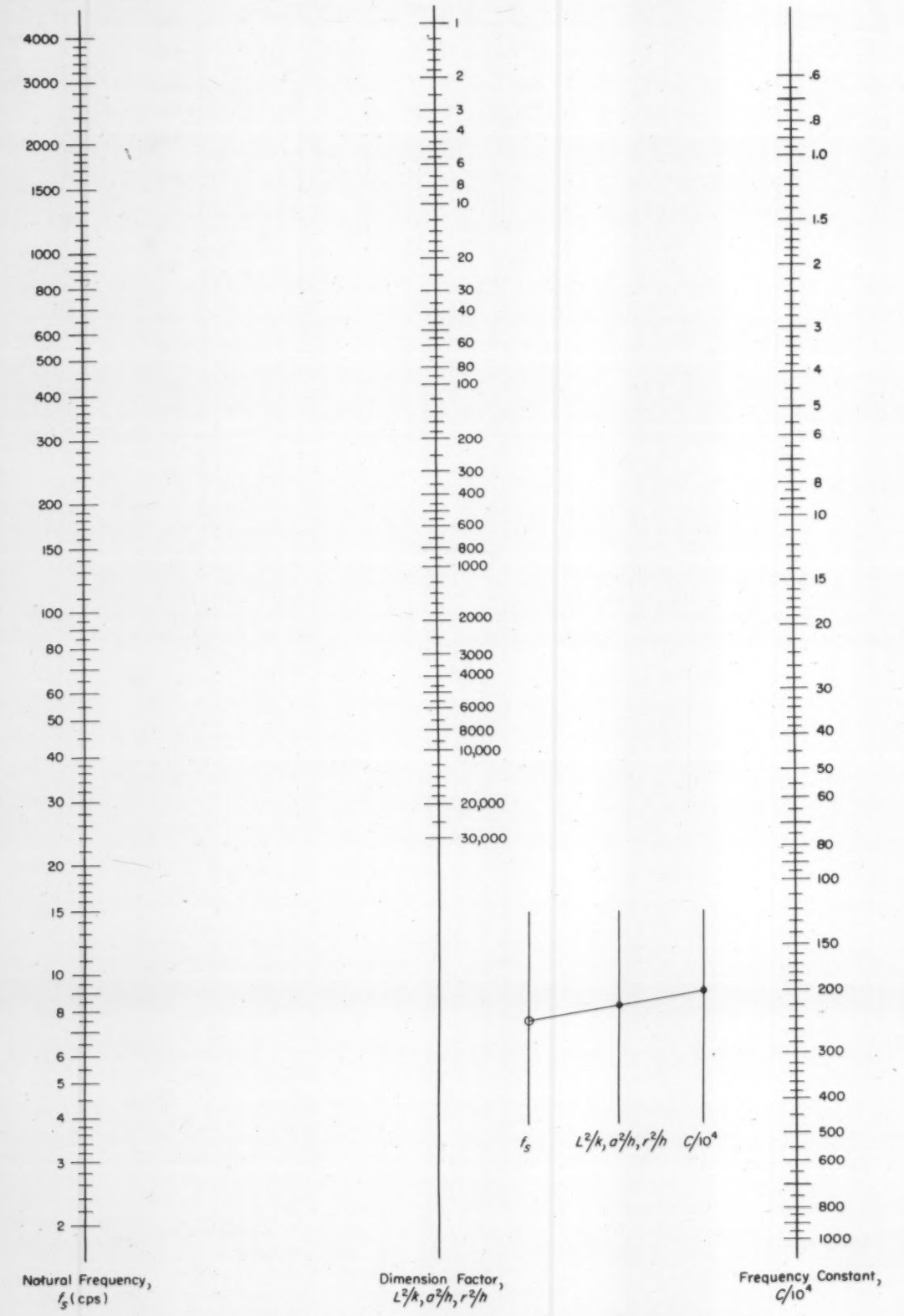
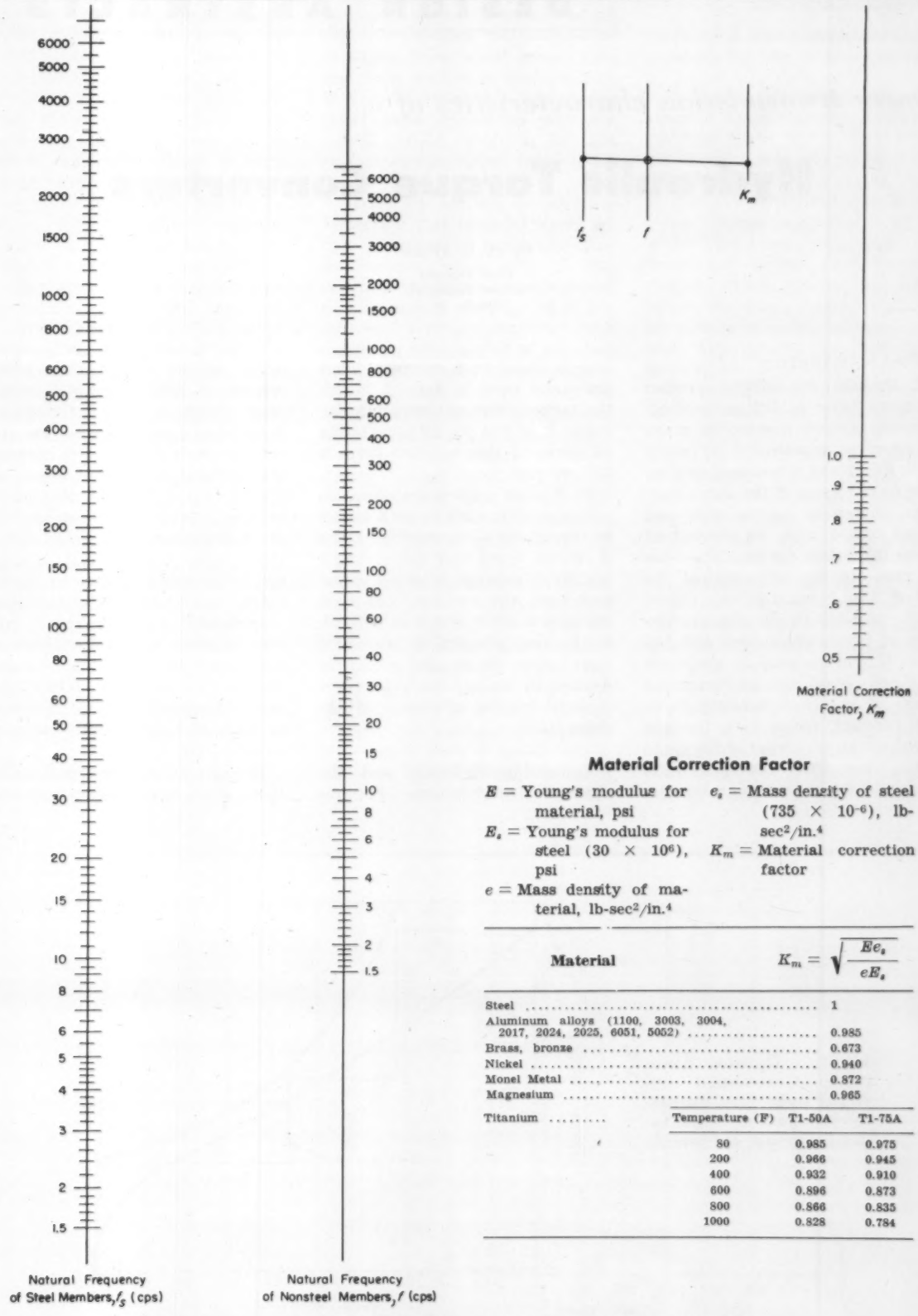


Fig. 3—Nomograph for alternate solution of natural frequency f_s from frequency constant C and dimension factor determined from Fig. 2.



Material Correction Factor

E = Young's modulus for material, psi

E_s = Young's modulus for steel (30×10^6), psi

e = Mass density of material, lb-sec^2/in.^{4}

e_s = Mass density of steel (735×10^{-6}), lb-sec^2/in.^{4}

K_m = Material correction factor

Material	$K_m = \sqrt{\frac{Ee_s}{eE_s}}$		
Steel	1		
Aluminum alloys (1100, 3003, 3004, 2017, 2024, 2025, 6051, 5052)	0.985		
Brass, bronze	0.673		
Nickel	0.940		
Monel Metal	0.872		
Magnesium	0.965		
Titanium	Temperature (F)	T1-50A	T1-75A
	80	0.985	0.975
	200	0.966	0.945
	400	0.932	0.910
	600	0.896	0.873
	800	0.866	0.835
	1000	0.828	0.784

Fig. 4—Correction table and nomograph for determination of correction factor K_m and natural frequency f for nonsteel structures.

Power transmission characteristics of

Hydraulic Torque Converters

By H. L. Wilke
Chief Engineer
National Supply Co.
Toledo, O.

TRANSMISSION of power through an infinite number of speed ratios at 100 per cent efficiency through a complete range of speed is represented by curve *A* in Fig. 1 and subsequent graphs. The co-ordinates of the curve have been chosen as torque ratio and speed ratio, and the product of these two values for any type drive is equal to the efficiency of the drive. This formula is very important, particularly in the application of torque converters, and frequently can be used to great advantage. Since the efficiency for curve *A* has been assumed to be 100 per cent, torque ratio becomes equal to the reciprocal of the speed ratio; thus, when the speed ratio is equal to 1, the torque ratio likewise is equal to 1, whereas, when the speed ratio is reduced to 0.5, the torque ratio automatically becomes 2, and so on, all because the efficiency of this mythical drive is 100 per cent.

The loads under consideration are those that vary in both torque and speed, for obviously from curve *A*, if the speed and torque ratios are fixed between a prime mover and load, the simplest and most economical drive would be a fixed-ratio drive adapted to the speed and torque ratios, and would be limited in its approach of curve *A* only by the efficiency of the drive itself.

Comparing Hydraulic and Mechanical Transmissions: For the loads under consideration, the earliest established and still prominent drive is the multispeed mechanical transmission. Its approach to the optimum power-transmission curve is shown in Fig. 1, curve *B*. For simplicity, in this example, the mechanical drive is assumed to have three speed ratios and to have the ability to multiply torque by three times. The mechanical multispeed transmission is not limited in any way to these assumed conditions, and as will be shown later, by additional transmission ratios the power transmitted at any point can be made to approach the optimum more closely.

In Fig. 1 the assumption is made that for any transmission ratio the

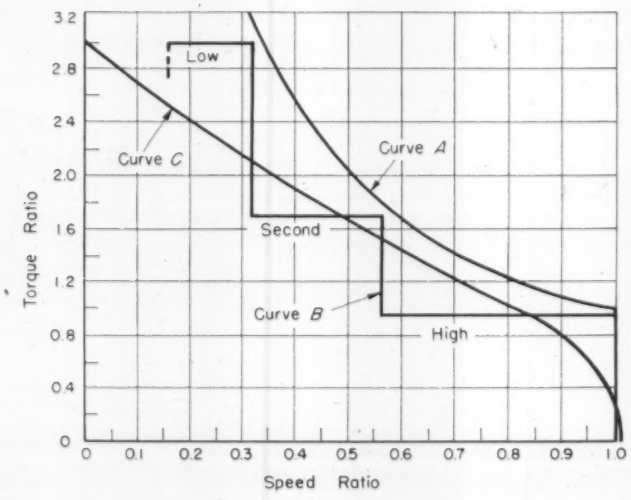


Fig. 1 — Optimum power curve, *A*, compared with typical three-speed mechanical transmission, *B*, and hydraulic torque converter, *C*.

efficiency can be made to be 95 per cent, but with a substantially constant-torque prime mover, the mechanical drive can deliver to the load 95 per cent of the power capacity at only one point for each of the speeds.

During all other parts of the speed range the engine is being pulled down in speed, but it cannot materially increase the torque, so it fails to deliver sufficient power until the next lower transmission speed can be engaged.

The power delivered by a torque converter against the same assumed conditions has been superimposed on the curves of Fig. 1 as is shown by curve *C*. The power delivered by the torque converter can be seen to be a smooth curve traversing the entire speed range. Since a torque conventer with a 3-to-1 torque ratio can be readily built to have 90 per cent peak efficiency, its power delivery approaches the optimum power curve almost as closely as the mechanical multispeed transmission and maintains this closeness over a considerable span of speed ranges. Torque converters are most adaptable for loads that rapidly vary back and forth through these speed ranges. This is because the torque converter can supply an infinite number of speed ratios, and as a result it can keep the engine at substantially maximum power-generating capacity. Unfortunately, the efficiency of the hydraulic torque converter cannot be maintained throughout the speed range, and, therefore, the torque drops to zero at a speed ratio of 1, and as the speed ratio approaches zero the output torque increases, but not as fast as the output speed is reduced.

Versatility of the torque converter for that range of speed ratios where it is most adaptable is demonstrated in Fig. 2. Between a multispeed transmission with maximum efficiency of 95 per cent and a torque converter with maximum efficiency of 90 per cent, for the multispeed transmission to excel throughout the range of speeds, a mechanical transmission with 10 speeds would be needed. Many of these speeds would be closely spaced, and the normal operator would find it most difficult to know which mechanical speed to use to maintain an advantage over the torque converter. Such a condition would almost certainly require automatic speed changes, which for heavy-duty industrial-type service might not always be mechanically satisfactory.

A more practical comparison would be such as is shown in Fig. 3 where the mechanical transmission would have 5 speed ratios, but even then during the speed ratios between 0.35 and 0.9 the mechanical transmission is hardly a match for the torque converter.

Combined Hydraulic and Mechanical Transmissions: The comparisons made up to this point, while over a complete speed range, have been limited in torque ratio to that of the common type single-stage torque converter. Where either higher torque ratios are required or better performance toward either end of the speed range, the torque converter can be adapted to a multispeed transmission, with greatly improved characteristics.

Depending upon the characteristics of the load, supplementing the torque converter with a multiplicity of speeds may not always be necessary. Should the load require only high torque ratios, a single-speed ratio adapted to the output of the converter may suffice, and torque ratios up to 15 or 20 to 1 are not at all uncommon. Similarly, for loads requiring predominantly higher speed ratios a single speed-up ratio could be used to obtain speed ratios up to 5 or 6 without any material complexity.

Rarely would a single variable load be encountered which would require the combination of extremes mentioned for the single supplementary speed ratios, so in

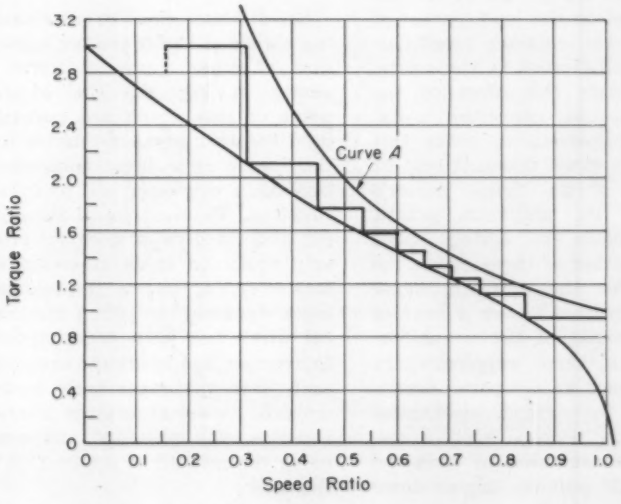


Fig. 2 — Power curves of torque converter and nine-speed gear transmission.

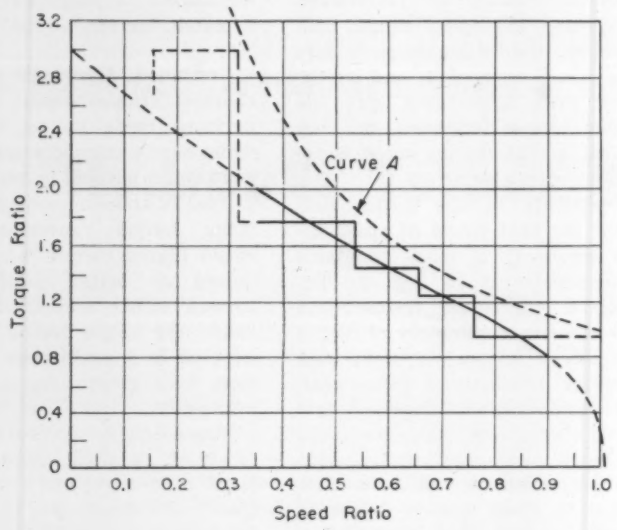


Fig. 3 — Power curves of torque converter and five-speed gear transmission.

the example for a three-speed supplementary multiple-speed transmission, more practical ratios will be illustrated. For example, with one ratio which would multiply the torque of the converter by 2½ and a high-speed ratio which would multiply speed by 2½ and a direct drive for the intermediate speed, results as shown in Fig. 4 would be obtained. The significant point to be observed in this figure, in the approach of the net results to the optimum power curve *A*, is that a minimum of 68 per cent of the prime mover's potential power can be delivered to the load, except of course at the extreme conditions which are indicated in the figure.

To evaluate the effect of the hydraulic torque converter, a six-speed transmission to cover this same range would transmit only 52 per cent of the prime mover's power at its minimum points, Fig. 5. Again, by adding speed ratios to either of these drives the approach to the optimum curve can be improved. (For a load of this wide variation, the torque converter with three supplementary speeds cannot be compared directly to a three-speed mechanical transmission because such a mechanical transmission to span the range would pull the engine down too much in speed, bringing it below its point of maximum torque, thus causing it to stall.)

A torque converter with supplementary speeds either manually or automatically shifted has a great variety of applications. These applications encompass all sorts of vehicular drives such as trucks, rubber-tired and crawler-type tractors, and locomotives. Other examples are logging machinery, oil-well drilling rigs, hoists, cranes and mining machinery, or any place where large torque and speed ranges are required and shock absorption is a desired quality.

Shock Absorption: Shock-absorbing ability of the converter against that of other types of drives is shown in Fig. 6. The co-ordinates of this graph are normally used for hydrodynamic drives and thus serve as a direct comparison between a converter and hydraulic coupling. The mechanical drive, being of a fixed ratio, does not properly apply to these co-ordinates; however, a curve approximating a dynamic load for a mechanical drive has been superimposed. Converters and hydraulic couplings each have the same basic hydrodynamic power-absorption characteristics, the principal difference being the method of application to the load.

Since the hydraulic coupling is a one-to-one torque-ratio device and the amount of slip necessary for the coupling to transmit the required torque must be chosen on the basis of a reasonable efficiency, a properly proportioned coupling will behave approximately like that illustrated in Fig. 6. The usual practice is to establish slip for 100 per cent torque equal to approximately 7 per cent, and so the hydraulic coupling's power-absorption characteristic plotted against slip appears as shown. The coupling potentially can absorb torques up to twice as much as the design torque. Normally, this excess torque capacity of the hydraulic coupling is not utilized, as the prime mover is proportioned to deliver torques nearer the designed torque. During a shock, however, the inertia values of the prime mover may be sufficient to supply at least a portion of the excess torque capacity of the coupling. This action is a great deal softer than the same sort of shock through a mechanical drive, for the latter fails to limit inertia values of the engine at all and does not provide slip such as the hydraulic coupling.

By comparison, the torque converter is considerably softer against shock. In the first place, the converter's size is proportioned so that its peak power-absorbing ability substantially matches the

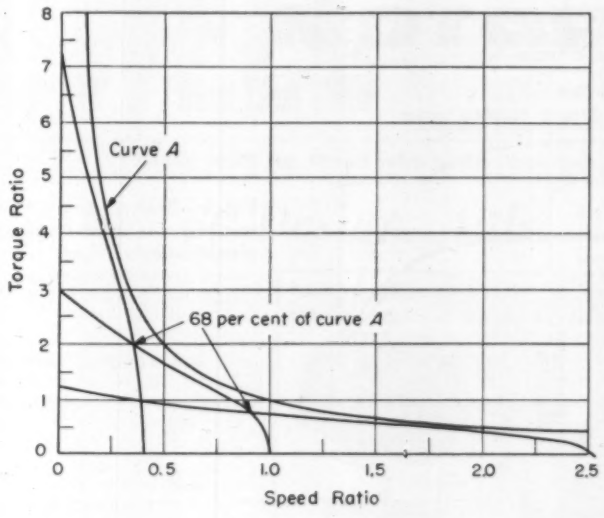


Fig. 4 — Power curves of torque converter with three-speed supplementary transmission.

engine's designed torque rating. Therefore, regardless of what happens to the output shaft in suddenness of load application, the demand on the engine can only be for its rated torque, and the effect of its inertia is entirely isolated. Beyond this degree of softness, to establish a torque multiplication of as much as two to one, the output shaft of a single-stage converter needs to be stalled down to approximately 0.3 speed ratio, and at the reduced speed the shock may be maintained. Even a three-stage converter with its higher torque multiplication must be stalled to 0.4 speed ratio to obtain a 2-to-1 torque multiplication. Thus, the torque converter appears to have a wide margin of shock absorption over other types of drives, and power shovel application is proving this fact in practice.

Torque - Converter Accessories: Industrial converters are available with dumping valves and controls which make it possible to use the converter as a disconnect clutch by quickly emptying and refilling the working circuit.

Torque converters with free-

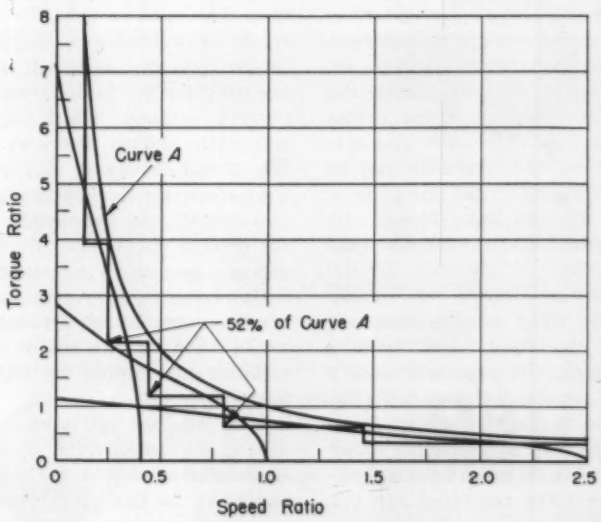


Fig. 5 — Power curves of torque converter with three-speed supplementary transmission compared with six-speed gear transmission.

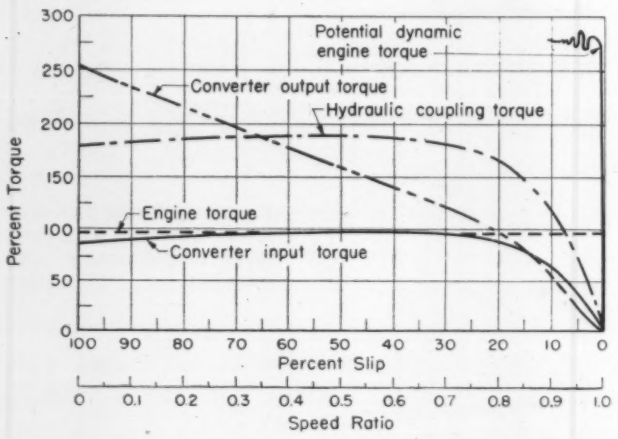


Fig. 6—Relative shock transmission of various power transmission devices.

wheeling stators are available as converter-couplings which serve as converters during periods of load variation and then as hydraulic couplings during periods of high-speed low-torque requirements. A good example for the use of this type converter is on an earth-moving scraper where, during loading periods, high torques are required, but during the hauling phase, high speeds and low torques are needed. The free-wheeling stator, changing the converter into a hydraulic coupling, performs the high-speed operation at a considerably increased efficiency.

Another feature, following closely the characteristics of the free-wheeling stator-type converter, is the converter which is equipped with a lockout clutch. Here again the converter is used during the high torque-load changing cycles following which the input and output sides of the converter can be clutched together to serve as a straight-through drive. This can be accomplished either with the converter filled or emptied. If the converter is allowed to remain filled, the drag of the elements through the fluid, even with a fixed stator, will represent only a loss of from 5 to 10 per cent, but it retains the advantage of being instantaneously available for either type of drive. Where fewer maneuvers permit the emptying and filling of the converter, this loss can be eliminated through the addition of the dumping and filling feature.

A recent addition to the available features on torque converters is the ability to run the converter partially filled. This serves the purpose where speed control is desired beyond the range of that of the prime mover. The conventional torque converter can be brought to stall even at full input speed, but only if the torque load on the output shaft is sufficient. Partial filling can be made to reduce the output-shaft speeds to substantially stall conditions even under light torque loads.

Reversing torque converters can be accomplished in a number of ways, at least two of which have been developed already. There currently is available a single-stage torque converter in which turbines are provided for both forward and reverse rotation which are mechanically shifted into and out of the circuit. Some of the original converters developed incorporated two circuits, one for ahead and one for reverse operations, which were put into service by alternately filling and dumping the circuits. Each of these reversing arrangements would have its own set of characteristics and would be adaptable to certain uses.

Still another variation of the torque converter which is definitely possible, but has not yet been exploited, is the ability to make it of high- and low-speed ratio characteristics. Conventional industrial torque converters have their peak efficiencies at speed ratios of from 0.5 to 0.7, but by altering the blade shapes and number of stages the peak efficiency can be made to appear at most any speed ratio from values as low as 0.1 to as high as 1.0.

Combinations of these features superimposed on the basic characteristics of torque converters have caused torque converters to be considered for applications where in the past they have been completely disregarded. For example, certain marine drives are now being considered which would incorporate the following features in addition to the normal torque-converter characteristics. They could incorporate a reverse to reduce maintenance incurred by present reversing means. Dumping and filling probably would be required by the reversing means, but also would serve as a disconnect clutch between the prime mover and the propeller. Partial filling would be incorporated to extend propeller-shaft speed control beyond that available from the prime mover. A low ratio might be incorporated to eliminate the speed-reducing element of the conventional drive so as to combine all of a ship's drive function into a single unit.

From a paper entitled "Torque Converters—A Flexible Drive" presented at the ASME Annual Meeting in New York, November, 1956.

HOWELL MOTOR BRIEFS

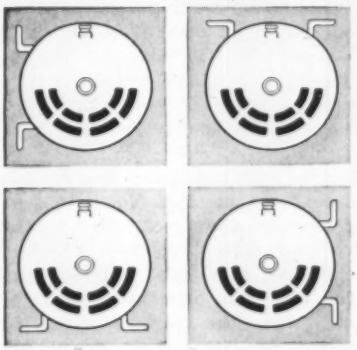
Quick facts for those who apply and specify electric motors

Flexibility of Design Aids Motor Applications

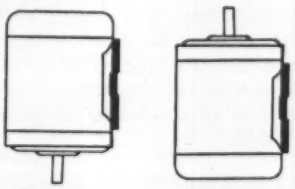
When they originally embarked upon the program of developing the basic Series 100 motor design for the new rerated frame sizes, Howell engineers set goals considerably above and beyond the requirements of the NEMA specifications. Among them, "maximum flexibility" of design was achieved to a degree that is outstanding in the motor industry . . . and that directly benefits machine designers who utilize standard motors.

Involved is not only unusual flexibility of positioning and lead connections, but a ready interchangeability of the five basic enclosure types within each frame size.

DESIGNED FOR MOUNTING IN ANY OF SIX POSITIONS

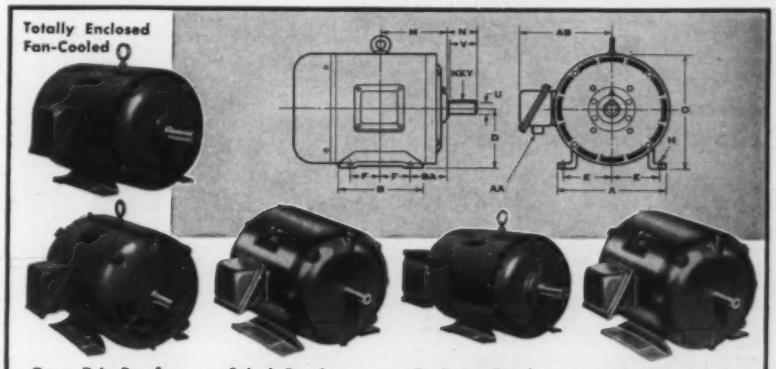


As illustrated by the diagrams above, Howell Series 100 Open Drip-Proof motors can be side-wall or ceiling mounted simply by revolving the end plates. The other four basic enclosure types do not even require this simple change.

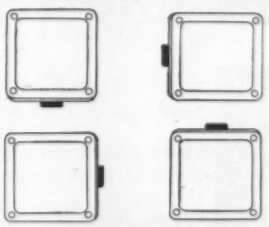


SHAFT DOWN SHAFT UP

Series 100 Totally Enclosed Fan-Cooled motors — in fact all of the five enclosure types — can also be mounted shaft down or shaft up with no modification in design required.

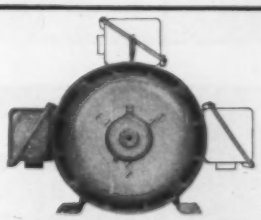


FIVE BASIC SERIES 100 ENCLOSURES HAVE SAME DIAMETERS, SHAFT AND MOUNTING DIMENSIONS — Unlike many other motors, the basic Howell Series 100 enclosures do not vary in diameter (or any of the essential mounting dimensions, except length) from one type to another (except a few 2-pole ratings). This is because of the way Howell accomplishes motor cooling, with "heat source" ventilation ducts in the stator itself . . . not by enlarging Totally Enclosed Fan-Cooled or Explosion-Proof frame diameters. This uniformity simplifies space allocations for the machine designer and allows for interchangeability of enclosure types to meet varying job requirements.



BOX EASILY ROTATED FOR 4-WAY HUB LOCATION

Series 100 conduit boxes are mounted to the frames with 4 screws, accessible for easy rotation of the box so that the integral, threaded nipple takes conduit from any of four directions.



CONDUIT BOX LOCATES TO FIT ANY REQUIREMENTS

For further flexibility, a simple modification can be specified for positioning of the conduit box in any of three positions around Series 100 frames.

GET COMPLETE DETAILS WRITE FOR BULLETIN N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

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Circle 461 on page 19

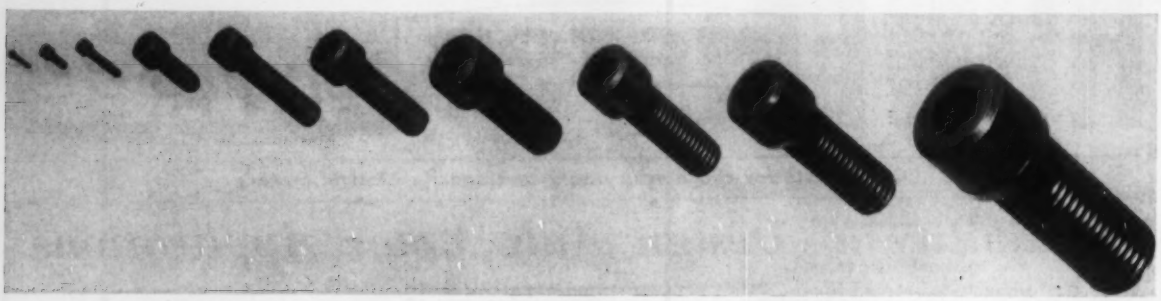

Fig. 1—Socket head cap screws, which are available in American Standard sizes from No. 0 (0.060-in.) to 1½-in. diam.

Revised American Standards allow broader applications of

Socket Head Cap and Set Screws

By F. W. Helming Sr.
Assistant Works Manager
Bristol Co.
Waterbury, Conn.

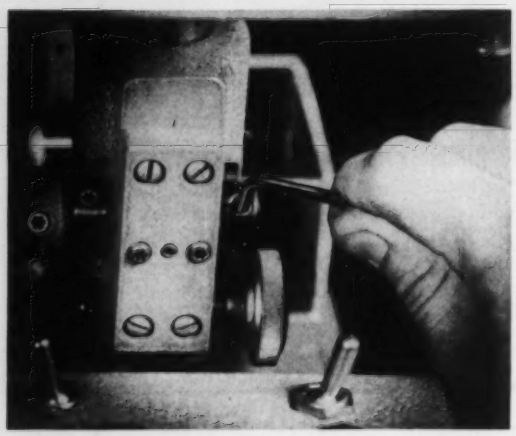

Fig. 2—Tightening recessed socket screws having fluted sockets. Alloy steel fluted keys permit application of maximum torque.

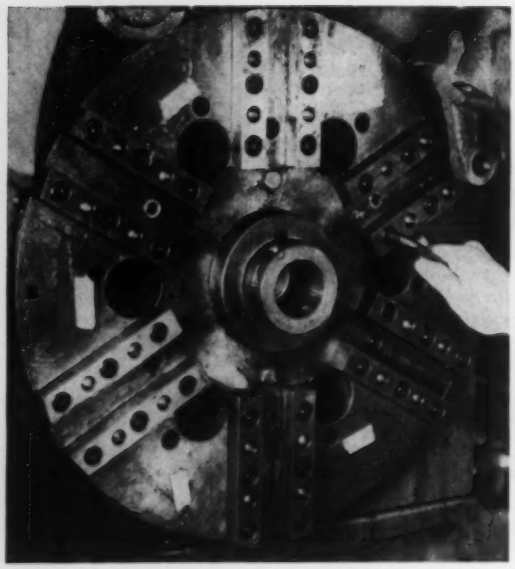

Fig. 3—Recessed socket cap screws used as fasteners on the end plate of an automatic screw machine. Design allows smooth revolving surfaces, without danger from protruding screw heads.

THE current American Standard for socket screws includes dimensional data covering socket-head cap screws with hex and fluted sockets in sizes from No. 0 to 1½-in. diameter inclusive, Fig. 1. Socket-head shoulder screws (stripper bolts) with hex and fluted sockets are shown in sizes from ¼ to 1¼-in. diameter. Socket set screws with hex and fluted sockets are shown in sizes No. 0 to 2-in. diameter. Also included are the various types of points available—cup, flat, cone, oval, half dog and full dog. Hex and fluted keys for use with the various types of screws are also shown in the full range of sizes.

Recessed socket screws are classified as a high-strength fastener. The type of alloy steel used permits heat treating to high strength levels with good all-around physical properties. The design of the socket provides for positive wrenching, while the type of alloy steel used in the key permits maximum torque to be applied to the fastener, Fig. 2.

Advantages: The design of the hex or fluted recessed-type socket is very advantageous from the designer's standpoint. When used in conjunction with revolving equipment, the screw may be recessed completely below the surface, thus

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Uniform spring quality is achieved at ALCO through coordination of many production steps into a single, automated operation. ALCO "Performance Rated" springs range from small springs for light industrial work to heavy-duty hot-wound springs with huge absorbing capabilities. Millions are in daily use on equipment throughout the world.

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Investigate ALCO for "Performance Rated" helical compression, extension, torsion, elliptical, volute, flat, belleville disk or other special type springs. Complete shot-peening facilities are also available. Call your nearest ALCO Sales Office or write Spring & Forge Division, Dept. SG-1, P.O. Box 1065, Schenectady 1, New York, for a copy of Booklet RS-2, "ALCO Springs For Industry."

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NEW YORK

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Locomotives • Diesel Engines • Nuclear Reactors • Heat Exchangers • Springs • Steel Pipe • Forgings • Weldments • Oil-Field Equipment

Circle 462 on page 19

eliminating any dangerous protrusion that might tend to catch on clothing, Fig. 3. Also, this convenient recessing feature permits cleaner, more streamlined design on new equipment.

An important advantage to be gained in using this type of fastener in machine assembly is the reduced size of the boss that may be used, Fig. 4. The ordinary hex-head cap screw requires a comparatively large boss due to the large-size screw and the amount of clearance needed for the external wrench. The high-strength socket-head cap screw permits the use of a smaller screw, and does not require additional clearance for the key because of the internal wrenching feature.

Socket set screws have received wide acceptance in all types of applications where good holding power is a requisite, Fig. 5. The high-strength characteristics permit maximum tightening torque to insure parts being held in proper position. The positive drive characteristics of this type fastener, in combination with an L-shaped key, provide for easy assembly in awkward locations.

The recent trend toward miniaturization has increased the demand for socket-type screws, Fig. 6. In practically every field of endeavor, the tendency is to reduce size and weight wherever possible and still maintain adequate strength levels comparable to the previous design. This is a logical place for using socket screws. The same trend also pushed the development of the miniature screws as small as No. 0 size (0.060-in. diam), for use in electronic equipment, radio, radar, etc.

From "Socket Head Cap and Socket Set Screws" in Industrial Fasteners, *Fall,* 1956.

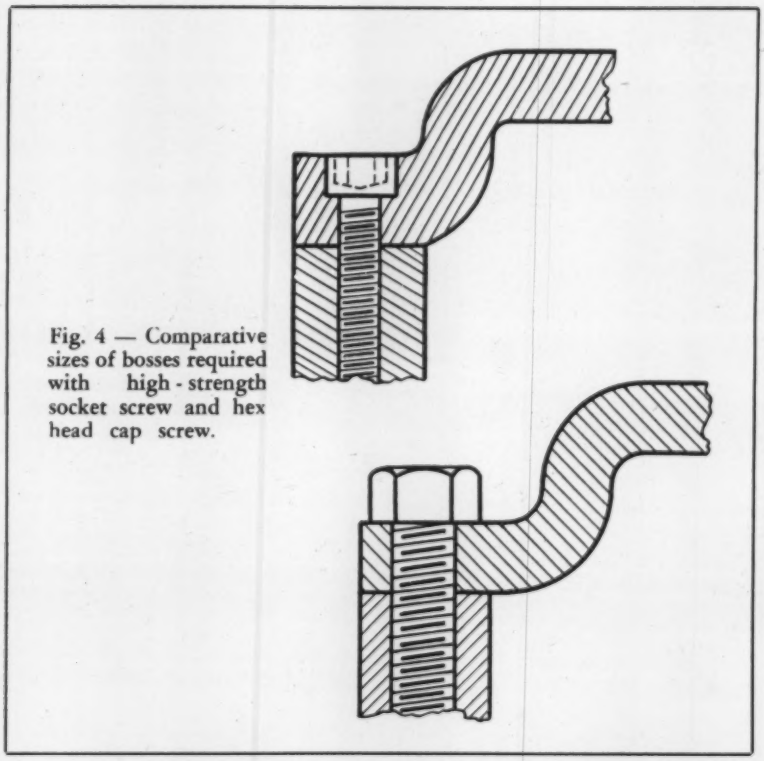


Fig. 4 — Comparative sizes of bosses required with high-strength socket screw and hex head cap screw.

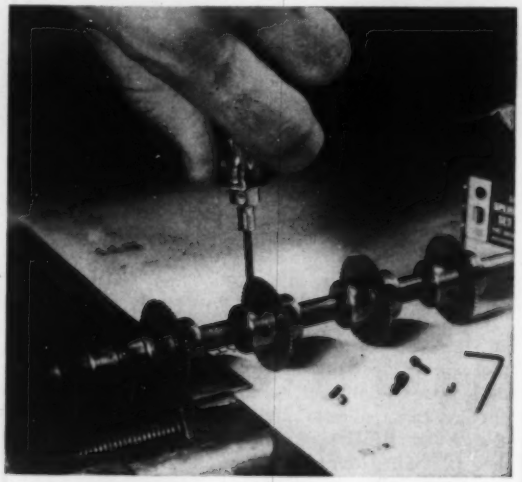


Fig. 5 — Socket set screws, used to hold perforating cutters on a revolving shaft. Internal wrenching feature of the socket screw allows tighter setting, and the screw is less liable to loosen during service.

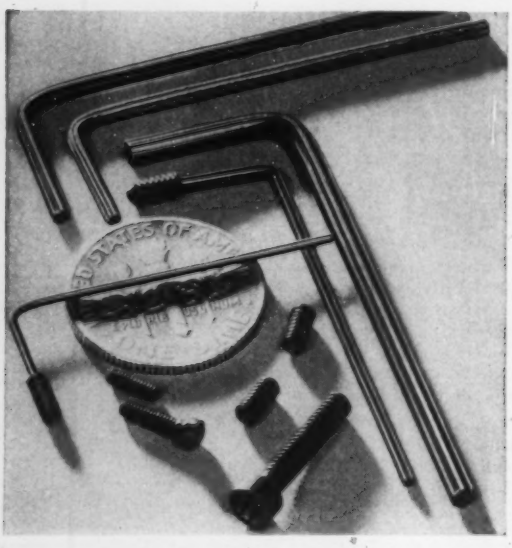


Fig. 6 — Miniature socket cap and set screws with their keys and a dime. These screws are now included in the American Standard down to No. 0 (0.060-in.) wire size, in hex and fluted sockets.

Microton hardness test typifies quality control measures that leave nothing to chance at Automatic Electric

STANDARDS THAT DETERMINE RELAY QUALITY

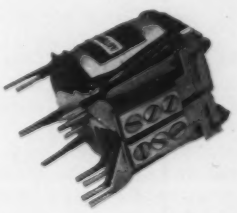
the ideal relay iron

Only soft, pure iron assures proper release, even after millions of operations.

In service, many relays get progressively slower to release, until finally the armature hangs up permanently. Excessively "hard" magnetic relay iron often is to blame. But in all Automatic Electric relays, the magnetic iron is so soft and pure that it saturates quickly, yet the flux dies out instantly. Even after millions of operations!

This improved relay iron is made and rolled to our own exacting specifications. Chemical analysis then makes certain that no magnetic capabilities have been lost. Annealing is rigidly controlled, and grain size and temper carefully checked. Elongation, hardness, permeability, and density tests further safeguard this pampered material. Result: not the *ideal* relay iron, but *the most nearly perfect iron available.*

This is no isolated example. Exhaustive tests prove that all our raw material is equally fine. It's one of the many reasons why Automatic Electric relays enjoy far longer life.



Series SQPC Relay for printed circuitry applications. *Write today for Bulletin RH-9. Automatic Electric Sales Corporation, Chicago 7.* In Canada: *Automatic Electric Sales (Canada) Ltd., Toronto.* Offices in principal cities.

AUTOMATIC ELECTRIC

Originators of the dial telephone · Pioneers in automatic control

GENERAL TELEPHONE SYSTEM

Circle 463 on page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Locknuts

Basic engineering data are given on ¼ to 3-in. hexagon nuts, ¼ to ⅝-in. 12-pointer nuts and ¼ to 1½-in. Huglock and Marsden locknuts in condensed catalog. Also offered is 24-page engineering data section on these products. 8 pages. National Machine Products Co.

Circle 601 on page 19

Metal Laminates

Types, metals, applications, advantages, properties and sizes of duplex and triplex metal laminates are covered in brochure 10NE6. Kitchen utensil, heat exchanger, automotive, major appliance and electronic uses are detailed. 8 pages. Bridgeport Brass Co.

Circle 602 on page 19

Pressure Gages

Deflection of bourdon tube or pressure cell is transmitted to pointer without gears in Bandrive pressure gages. Bulletin 403A lists specs and characteristics of gages with ranges from 0-60 to 0-20,000 psi. 4 pages. Norden-Ketay Corp.

Circle 603 on page 19

Molding Materials & Resins

Brochure CDC-322 provides technical data, properties and product features of phenolic molding powders, rubber phenolic molding powders, phenolic laminating varnishes and industrial and foundry resins. 12 pages. General Electric Co.

Circle 604 on page 19

Cold Headed Fastener

Catalog "Job Designed Cold Headed Fasteners" shows the design possibilities in rivet, nail and threaded parts manufactured by cold heading and cold forging process. Sizes range from 0.024 to ⅜-in. diameter. 4 pages. John Hassall, Inc.

Circle 605 on page 19

Meters

Line of meters for factory, field and laboratory use features better than 0.25-per cent accuracy. Readings of up to 1 million ohms per volt are possible. Brochure describes variety of scales and ranges available. 8 pages. Greibach Instruments Corp.

Circle 606 on page 19

Subminiature Switches

Data sheet 237-1 describes subminiature lever switches, with and without spring return action, for use on transistorized and miniaturized electrical and electronic equipment. 2 pages. International Instruments, Inc.

Circle 607 on page 19

Gas Appliance Pilot

Operational and installation information on the Mini-Pilot miniature gas appliance pilot is offered in data sheet GS-76, along with cutaway diagram. Robertshaw-Fulton Controls Co., Grayson Controls Div.

Circle 608 on page 19

PVC Plastic Valves

Corrosion resistance requirements of modern fluid systems are met by series of PVC-Micro-Meter needle and Micro-Flow globe valves described in brochure. Valves can have Teflon and Kel-F trim and stainless steel reinforcement. 4 pages. Chemtrol Corp.

Circle 609 on page 19

Special Fasteners

Over 100 special plated and case-hardened fasteners designed by or for customers are illustrated and briefly described in booklet. 16 pages. Buffalo Bolt Co.

Circle 610 on page 19

Semiautomatic Lubricators

Operation and service of push-type 1 and 2-pt reservoir semiautomatic lubricators are discussed in instruction sheet. Both are actuated by spring discharge piston pump that feeds oil into distribution system. 2 pages. Bijur Lubricating Corp.

Circle 611 on page 19

Aluminum Welding Electrode

Folder TIS 2891 on Low Amp EutecTrode 2101 DC tells how to "Arc Weld Aluminum as Easily as Mild Steel." Advantages of an extruded coating on aluminum electrodes are explained. Case histories point up properties of joint. Eutectic Welding Alloys Corp.

Circle 612 on page 19

Flow & Pressure Instruments

Products available for immediate shipment, such as indicating, recording, controlling and transmitting instruments for flow, pressure and density, are described in catalog 2. Air and water meter capacities are given. 32 pages. Fischer & Porter Co.

Circle 613 on page 19

Airborne Switches

Enclosed switches for airborne equipment are subject of comprehensive catalog 77. Many units are suitable for railway, marine and mobile applications. Variety of actuator designs, electrical ratings and contact arrangements is available. 24 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 614 on page 19

Steel Pipe & Fittings

Technical data card 152-A on Croloy steel pipe, tubing and welding fittings covers mechanical and physical properties, hot and cold bending, welding and heat treatment. Maximum steam limit is 1050° F. 4 pages. Babcock & Wilcox Co., Tubular Products Div.

Circle 615 on page 19

Electronic Instruments

Concise, condensed data on electronic counting, timing and controlling instruments are presented in new Short Form catalog. Also covered are research, engineering, manufacturing and service facilities of this company. 6 pages. Computer-Measurements Corp.

Circle 616 on page 19

Pressure Gages

Dial type pressure gages for such equipment as engines, turbines, presses, tractors, pumps and compressors are subject of bulletin DH-23. Offered with various gages to withstand heat, pressure, problem

You already depend on a Leland explosion-proof!

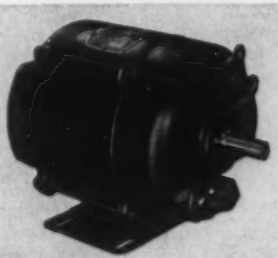
7 of every 10 gasoline pumps are powered by Leland

Next time you have your gas tank filled – quickly and safely, whatever the weather – odds are *better than 2 to 1* that a *Leland* motor will pump the gasoline.

For ever since Leland introduced the *first* explosion-proof gasoline pump motor, over 30 years ago, Leland gas pump motors have *outsold all others combined!*

Odds are you'll find Leland your finest source for explosion-proof motors of *all* kinds – from pumping volatile liquids and gases to powering equipment in hazardous atmospheres. There's a complete line of explosion-proof motors from ⅛ to 5 hp – and, if necessary, the experienced engineering ability to *develop* an explosion-proof motor to meet your most demanding requirements.

Next time you need a motor, standard *or* special, explosion-proof or otherwise, try Leland.



Leland explosion-proof gasoline pump motor, Underwriters' Approved for Class 1, Group D, Capacitor start, induction run, with built-in voltage changer and on-off switch.

Another AMF Product

LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY

Circle 464 on page 19

chemicals or fluids, pressure pulsations and vibrations. 4 pages. American Chain & Cable Co., Helicoid Gage Div.

Circle 617 on page 19

Fluid Pumps

Four models of cartridge type lubrication pumps with capacities up to 170 gph at 200 psi are described in illustrated catalog sheet No. 108. Both nondirectional and automatic reversing types are shown. 2 pages. Tuthill Pump Co.

Circle 618 on page 19

Die Sets & Accessories

Comprehensive technical section is combined with a net price list in well-illustrated catalog No. 11 on die sets and accesories. "How to" information is offered on design and application of dies. Catalog is arranged for quick reference. 76 pages. Producto Machine Co.

Circle 619 on page 19

Rope-Like Adhesives

Thermoplastic adhesive is offered in coiled rope-like form to facilitate bonding kraft, plastic films, foils, fabrics and other materials. Ten advantages of this adhesive are explained in bulletin "Thermogrip". Also described is machine for applying adhesive on straight-line gluing applications. 6 pages. United Shoe Machinery Corp.

Circle 620 on page 19

Flexible Hose Assemblies

Marine catalog 301 covers flexible hose assemblies with detachable, reusable fittings for fuel, air, oil, water and hydraulic lines on commercial and Navy vessels. Aeroquip Corp.

Circle 621 on page 19

Special Hinges

"Here Is Important Design and Ordering Information About Stanley Special Hinges" is title of bulletin PM-2 which also gives details of hinge engineering and production facilities of this company. 4 pages. Stanley Works, Stanley Pressed Metal Div.

Circle 622 on page 19

Pipe Expansion Joints

Expansion joints for ½ to 6-in. pipe lines are available for practically every fluid service, according to illustrated bulletin. Threaded, flange and weld end expansion joints compensate for misalignment as well as expansion and contraction. 4 pages. Rotherm Engineering Co.

Circle 623 on page 19

Steel Forgings

Technical article "Modern Forge and Machine Service" discusses production facilities and techniques employed by this company. Also described are typical flat die steel forgings produced for industry. 4 pages. National Forge & Ordnance Co.

Circle 624 on page 19

Glass Fiber Products

Three kinds of flame-blown glass fiber insulations for thermal and acoustical applications are described in bulletin WPD-12. Charts and data are also included on quartz and glass micro-fibers, plastic reinforcing products, textile yarns and mat products. 6 pages. L.O.F. Glass Fibers Co.

Circle 625 on page 19

Copying Machine

Details of the new Zephyr Whiteprinting machine for printing and developing prints up to 42 in. wide at speeds to 25 fpm are given in illustrated bulletin 2591. Machine can be installed anywhere and reproduces from anything typed, written, drawn or photographed on reasonably translucent material. 8 pages. C. F. Pease Co.

Circle 626 on page 19

Drives & Accessories

Variable speed pulleys, wide V-belts, sheaves, motor bases, countershafts, Select-O-Speed transmissions, flexible couplings and universal joints are some of the products described in illustrated catalog "Power Transmission Equipment." Ratings and dimensions aid in design and application. 28 pages. Lovejoy Flexible Coupling Co.

Circle 627 on page 19

Relays & Switches

1956-57 catalog gives design and application data on forty different switches and relays ranging in size from standard to miniature. Available capacities, types and contact arrangements are tabulated. 12 pages. Jaidinger Mfg. Co.

Circle 628 on page 19

Tubular Electronic Parts

Revised information on cathodes and other electronic parts offered is related in text and tables of illustrated catalog No. 51. Described are cathodes for receiving, ray and transmitter tubes; anodes; fabricated tubular parts; and general purpose tubing. 20 pages. Superior Tube Co.

Circle 629 on page 19

Plastic Laminates

Comprehensive chart lists 28 electrical and physical properties of 11 standard grates of Glastic glass fiber reinforced plastic laminates. Both rigid and flexible types are available. Sheet sizes range to 36 x 72 in. with thicknesses to 1¼ in., depending upon grade. 4 pages. Glastic Corp.

Circle 630 on page 19

Industrial Engine

The Ford 254 industrial engine and power unit develops up to 94 hp at 2400 rpm. This 6-cylinder gasoline engine is adaptable for powering wide range of equipment. Specs are given for other 4, 6 and V-8 cylinder engines. 4 pages. Ford Motor Co., Industrial Engine Dept.

Circle 631 on page 19

Magnet Wire

Handy reference table for users of magnet wire presents electrical, physical and chemical properties of LectALite enameled magnet wire. It is suitable for equipment in the class B temperature range and is highly resistant to Freon. Specifications cover class O, A, B and H magnet wire. Electric Auto-Lite Co.

Circle 632 on page 19

Compressors & Vacuum Pumps

Rotary integral motor air compressors and vacuum pumps are subject of bulletins P-356 and V-356. Available are units with 1/12 to 1/3-hp motors for pressures to 25 psi and vacuums to 25 in. of mercury. 2 pages each. Gast Mfg. Co.

Circle 633 on page 19

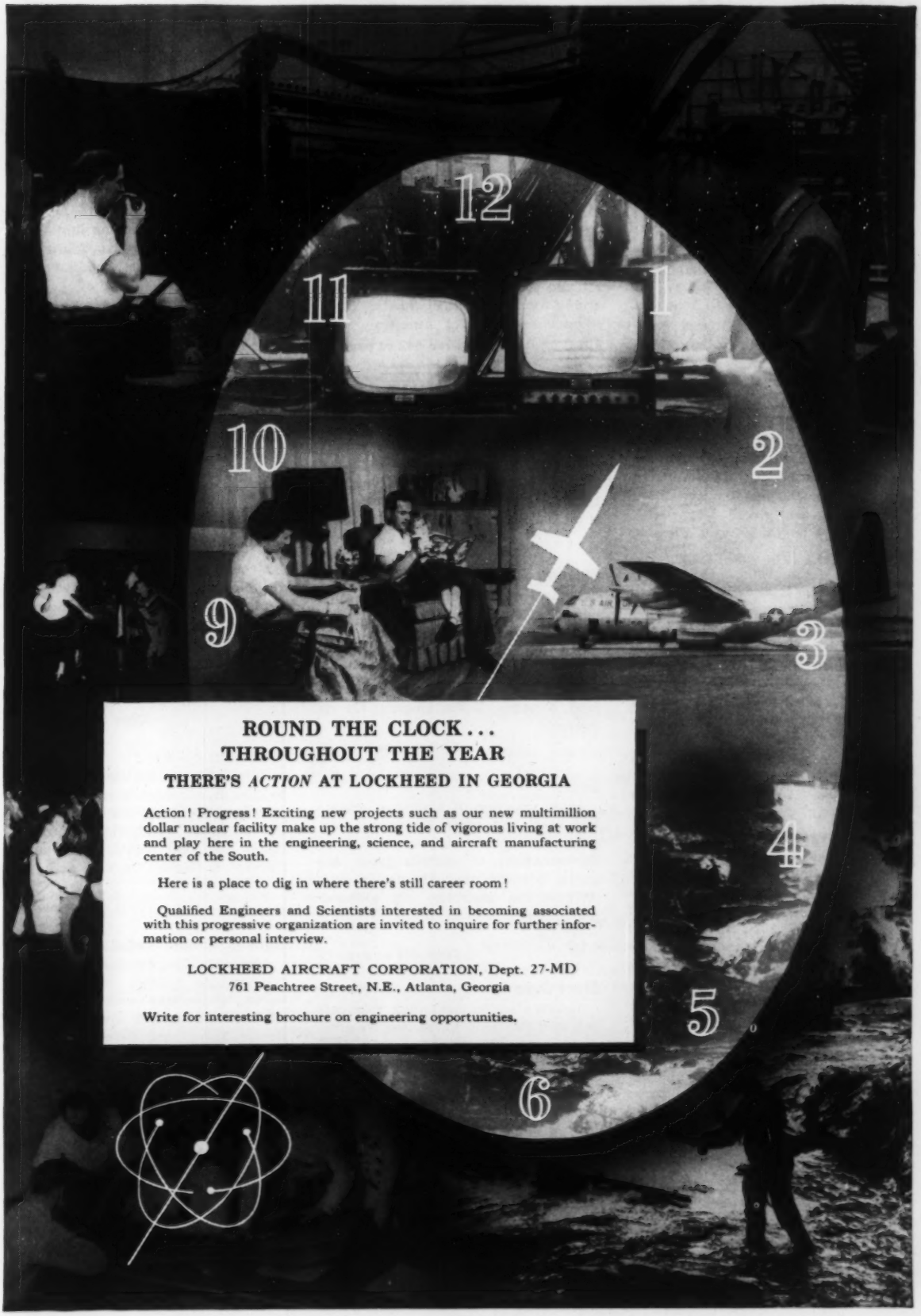
Speed Reducers

Complete specifications on foot and ring mounted Electra-Geareducers in ratios from 60:1 to 900:1 and ratings from 1/6 to 2 hp are given in illustrated section X of catalog 55. They feature aluminum housings. 12 pages. Electra Motors, Inc.

Circle 634 on page 19

Transformers

Electran transformers, saturable reactors, chokes, special windings and electronic devices which are engineered and constructed to specific



ROUND THE CLOCK...
THROUGHOUT THE YEAR

THERE'S *ACTION* AT LOCKHEED IN GEORGIA

Action! Progress! Exciting new projects such as our new multimillion dollar nuclear facility make up the strong tide of vigorous living at work and play here in the engineering, science, and aircraft manufacturing center of the South.

Here is a place to dig in where there's still career room!

Qualified Engineers and Scientists interested in becoming associated with this progressive organization are invited to inquire for further information or personal interview.

LOCKHEED AIRCRAFT CORPORATION, Dept. 27-MD
761 Peachtree Street, N.E., Atlanta, Georgia

Write for interesting brochure on engineering opportunities.

needs are described in bulletin 53. Accompanying bulletin 47B describes line of multipurpose step-down transformers for combination power and lighting circuits. 8 pages. Electran Mfg. Co.

Circle 635 on page 19

Magnetic Separators

Drum type magnetic separators for wet concentration and magnetic recovery are described in illustrated catalog 910. They utilize electro or Alnico permanent magnets. Specifications, application data and operating results are given. 16 pages. Jeffrey Mfg. Co.

Circle 636 on page 19

Flange Couplings

Space-saving type CF flange couplings for internal combustion engines are subject of bulletin 606. Application data for various industrial engine makes are given, along with dimensions. 4 pages. Lovejoy Flexible Coupling Co.

Circle 637 on page 19

Oil Seals

Standard designs available in metal OD and rubber elastomer OD oil seals are described and illustrated in catalog 305. Design features to be considered to assure desired performance are presented, as are recommendations for adaptability to pressure, temperature and shaft speed. 60 pages. Victor Mfg. & Gasket Co.

Circle 638 on page 19

V-Belt Driven Pumps

Heavy fuel oil and other noncorrosive viscous liquids can be handled by type SU pump units with multiple V-belt drives, subject of illustrated catalog section 107. Specifications, dimensional diagrams and design features are covered. 8 pages. Tuthill Pump Co.

Circle 639 on page 19

Molded Rubber Parts

Engineering consultation, compound selection, mold design and manufacture of custom molded rubber parts are detailed in illustrated brochure. Technical specifications include relative properties of natural and synthetic rubbers. 8 pages. Tyer Rubber Co., Molded Rubber Products Div.

Circle 640 on page 19

Welded Steel Tubing

Types of electric-resistance welded steel tubing available are listed in illustrated brochure. Technical data on the product, offered in various lengths, special shapes, varied finishes and types of steel, are included. 12 pages. Revere Copper & Brass Inc.

Circle 641 on page 19

Cast & Wrought Steels

"Fatigue Properties of Cast and Comparable Wrought Steels" is ASTM technical paper which covers effects of steel composition and heat treatment, surface finish, directionality and section size and 11 cast steel and 8 wrought steel heats. Steel Founders' Society of America.

Circle 642 on page 19

Air Motors & Compressors

How 35 product problems were solved with Gast rotary air motors, air compressors and vacuum pumps is shown in application ideas bulletin 1054. Three data sheets describe 1/20 to 4 hp air motors. Price list is included. 12 pages. Gast Mfg. Corp.

Circle 643 on page 19

Bushing Assemblies

Typical applications of heavy duty industrial and aircraft self-aligning bushing assemblies are presented in illustrated bulletin SF-86. Dimensions, weights, capacities, and shaft and housing fits and tolerances are covered. 8 pages. Roller Bearing Co. of America.

Circle 644 on page 19

Gears

Wide selection of aluminum, stainless steel and nylon precision stock gears is offered in catalog E-88. Specifications of various types are given. Also included are design kits, differentials, shafting, slip clutches and other items. 88 pages. Dynamic Gear Co.

Circle 645 on page 19

Steel Data

Information on machining, fabricating, specifications, tolerances, weights, dimensions, elements and safe loads of steel products is contained in pocket size steel data book. Tables, definitions and general data are included for wide variety of steels shapes and forms, 256 pages. Joseph T. Ryerson & Son, Inc.

Circle 646 on page 19

Socket Head Cap Screws

Increase in head diameters of 1⅛ to 3-in. socket head cap screws described in folder affords stronger assembly of heavy machinery components. Physical properties of larger sizes are detailed. 4 pages. Cleveland Cap Screw Co.

Circle 647 on page 19

Zirconium Alloy Tubing

Data on zirconium, Zircaloy-2 and Zircaloy-3 seamless tube are found in technical memo No. 112. Covered are uses, chemical analysis, mechanical properties, production limits, tolerances, shapes, lengths, fabrication information. 5 pages. Superior Tube Co.

Circle 648 on page 19

Air-Cooled Compressors

Line of small air-cooled compressors for industrial and general use described in bulletin AC-15 provide air for anything from hammers and hoists to vacuum cleaners. One and two-stage units for 85 to 175 psi are described. 16 pages. Gardner-Denver Co.

Circle 649 on page 19

Dilatometers

Mechanically recording and photographic dilatometers made by Chevenard of France are announced in loose-leaf folder. Instruments are for laboratories concerned with metals, ceramics and materials for nuclear physics, jet engines and atomic power. 16 pages. R. Y. Ferner Co.

Circle 650 on page 19

Hydraulic Fluids

"Ucon Hydrolubes Spell Safety" is booklet on advantages and limitations of water-base, fire-resistant CP hydraulic fluids which also afford corrosion and wear resistance. 16 pages. Carbide & Carbon Chemicals Co.

Circle 651 on page 19

Gate & Needle Valves

Material specifications, pressure-temperature ratings, working pressures, dimensions and applications of R-P&C's forged steel gate and needle valves are listed in bulletin DH-80. Valves are for petrochemical, power and process industries. 12 pages. American Chain & Cable Co., R-P&C Valve Div.

Circle 652 on page 19

Stainless Alloys

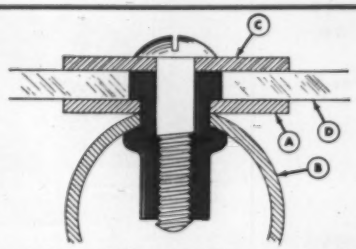
Blue Data Sheet provides details on intergranular corrosion, mechanical properties, analysis and stress rupture properties of chromium-nickel-manganese stainless steel types 202. 204 and 204L. 8 pages. Allegheny Ludlum Steel Corp.

Circle 653 on page 19

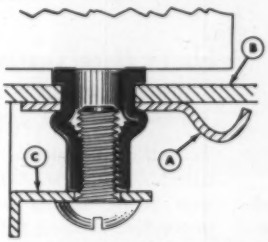
B.F.Goodrich Rivnut

cuts fastening time, saves money by doing two jobs in one operation!

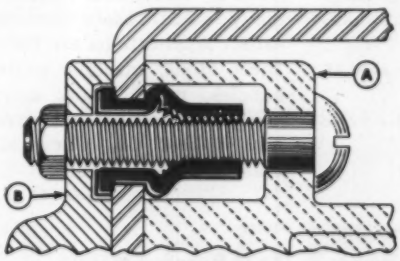
Do you have dual fastening problems like these?



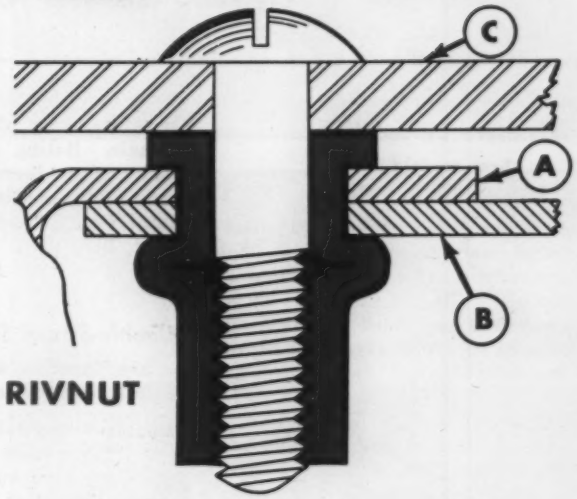
In airplane window seal, Rivnut rivets plate (A) to center post (B), provides nut plate to hold clamp strip (C). Rivnut head serves as spacer for transparent plastic sheets (D). Result: a neat, weather-tight seal!



In vaporizer assembly, Rivnut rivets upper flange (A) to casing (B), makes firm, accurate nut plate for attachment to lower flange (C). Rivnut eliminates reinforcing plate. Result: less assembly time, fewer parts, better product.



Rivnut provides 6-thread nut plate for attachment from either end—or *both*. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket (A). Plug base (B) is attached on other side. Result: fewer operations, lower assembly cost.



B. F. GOODRICH RIVNUTS cut costs and speed assembly because they rivet two parts together, make a firm, accurate nut plate for a third. And they do both jobs in one quick operation! Rivnuts can be installed from one side, take an attachment bolt from either end. They eliminate welding, tapping, clinching.

In the transformer assembly above, one worker fastens the metal cover (A) to the Glastic* sheet (B) with Rivnuts in seconds. Rivnuts then serve as mounting lugs for attaching completed transformer to mounting plate (C).

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs—can do the same for you.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy today by writing to: B. F. Goodrich Rivnuts, Dept. MD-27, Akron, Ohio.

*T. M. Reg. The Glastic Corp.

B.F.Goodrich

AVIATION PRODUCTS

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 466 on page 19

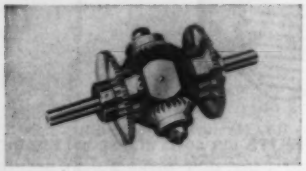
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Differential

in three models for torque to 150 oz-in.

Servo-component miniature differential has minimum backlash, high accuracy and low breakaway torque. Gleason-Coniflex bevel gears and preloaded ball bearings provide long life. Gears are AGMA Precision Class 2. Input gears are



piloted on same bearings as bevel gears for minimum runout. Three models have shaft sizes of ⅛ to ¼-in., breakaway torques of 0.060 to 0.065 oz-in., and maximum torques of 90 to 150 oz-in. at 1400 to 1500 rpm. **Helipot Corp.**, Newport Beach, Calif.

Circle 654 on page 19

Subminiature Switch

90-deg unit is screwdriver operated

Screwdriver-actuated switch can be installed in limited access areas for occasional use, as when testing a circuit. Unit is single-pole, single-

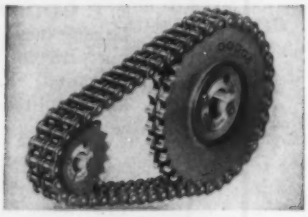
throw with slotted actuator head for 90-deg rotation. Visual indication of switch position is provided. Variations available are high-temperature, long life, or special terminals. Rating is 5 amp, 125/250 v ac, or 3 amp inductive at 30 v dc. **Minneapolis-Honeywell Regulator Co.**, Micro-Switch Div., Freeport, Ill.

Circle 655 on page 19

Double-Strand Sprocket

has Taper-Lock interchangeable bushing

Double-strand roller-chain sprocket has Taper-Lock interchangeable standard bore bushing. This provides equivalent of press fit to



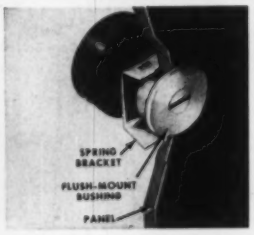
shafts with any surface finish and wide tolerances from nominal size. Pitch of sprocket ranges from ½ in. to 1 in. If sprocket becomes worn, bushing may be reused and only sprocket need be replaced. Sprockets up to 21-tooth size have hardened steel teeth. **Dodge Mfg. Corp.**, 1952 William St., Mishawaka, Ind.

Circle 656 on page 19

Bushing Mount

permits flush or recessed location of controls

Panel-mounting bracket for potentiometers, trimmer condensers, switches and tuned coils locates controls with shafts flush or recessed to prevent tampering or accidental misadjustment. Device consists of an internally threaded narrow-flanged bushing and a spring bracket which bears against back of panel. Unit mounts in 9/16-in. hole for control with ¼-



in. shaft, 7/16-in. hole for ⅛-in. shaft. Rubber O-ring and gasket provide panel seal. **Waters Mfg. Inc.**, Box 368, South Sudbury, Mass.

Circle 657 on page 19

Plastic Metal Coating

provides both decoration and protection

Versatile organosol formulation, based on Pliovic AO vinyl dispersion resin, forms decorative and protective coating for metals. Flow, viscosity and dispersion stability allow brush or spray application. Low plasticizer content produces hard coating with little tack and great chemical resistance. Vinyl resin is inert and unaffected by many acids, bases and metallic salts. Applications are for coating sheet stock, machine parts, tool handles, metal ducts, hoods and machine housings. **Goodyear Tire and Rubber Co.**, Chemical Div., Plastics Dept., Akron 16, Ohio.

Circle 658 on page 19

Cool-Running Motors

have tandem fans for straight-through ventilation

Re-rated Series 254U motors feature air flow over field-coil ends for low internal temperatures. Per-

more

Locking Power

... than any other washer or washer substitute

Shakeproof locking teeth can be incorporated into many types of lock washers ... for added strength, countersunk, and elongated holes, heavy-duty applications and other requirements.

- Shakeproof Lock Washers assure maximum vibration protection for your product
- Exclusive tapered-twisted teeth resist loosening • Assure maximum locking engagement • Form positive brace against rotation • Resist shock
- Available in nearly 500 job-tailored styles and wide size range.

Send for Shakeproof Lock Washer Sample Kit

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"FASTENING HEADQUARTERS"®

DIVISION OF ILLINOIS TOOL WORKS

St. Charles Road, Elgin Illinois • Offices in Principal Cities

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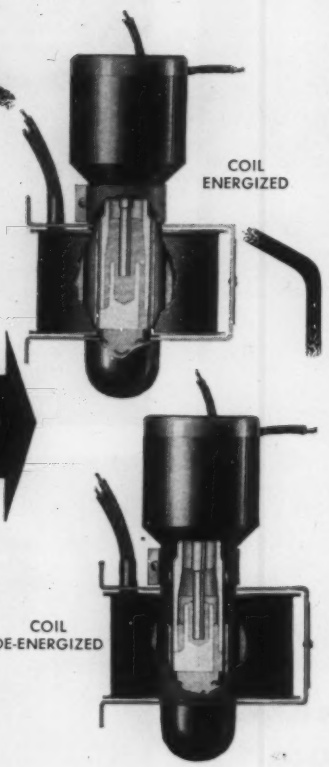
Circle 467 on page 19

The
TIMER RELAY
that handles all controlled timing problems . . .

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer

Durakool
STEEL MERCURY TIMERS



This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

See telephone directory for local distributor, or write.

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Circle 468 on page 19

SPECIAL
FABRICATION
Littleford's complete, top quality fabricating saves your time and facilities for your own specialty. Dependable deliveries. Send us your blueprints for prompt estimate. Littleford Bros., Inc., dept. LB-234, 424 E. Pearl St., Cincinnati 2, Ohio
1882 - 1957
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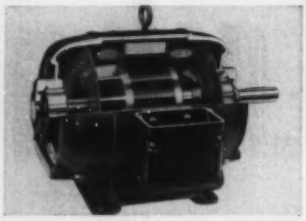
LITTLEFORD
CINCINNATI
FABRICATING SPECIALISTS

Circle 469 on page 19

New Parts

manent winding protection is provided by Mylar slot-cell insulation with cushioning paper backing. Removable cover plates on end-heads



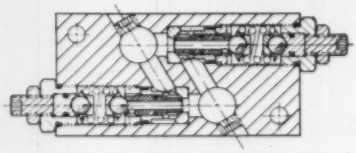
permit inspection of double-width bearings. Full-height end-heads protect motor against moisture and falling objects. **Robbins & Myers Inc.**, Springfield, Ohio.

Circle 659 on page 19

Relief Valves

dual units for fluid motors

Hydraulic relief valves, available in either guided-piston or differential-piston types, protect hydraulic components and systems from excessive pressures that occur when control valves are suddenly



reversed or blocked or when an external load is applied to a motor. They also assure smooth, safe starting and deceleration of heavy loads. Units consist of two integral relief valves which can be adjusted to the same or to different pressures. When oil pressure exceeds desired setting, oil is relieved from one line and directed into the other. **Fluid Controls Inc.**, 1284 N. Center St., Mentor, O.

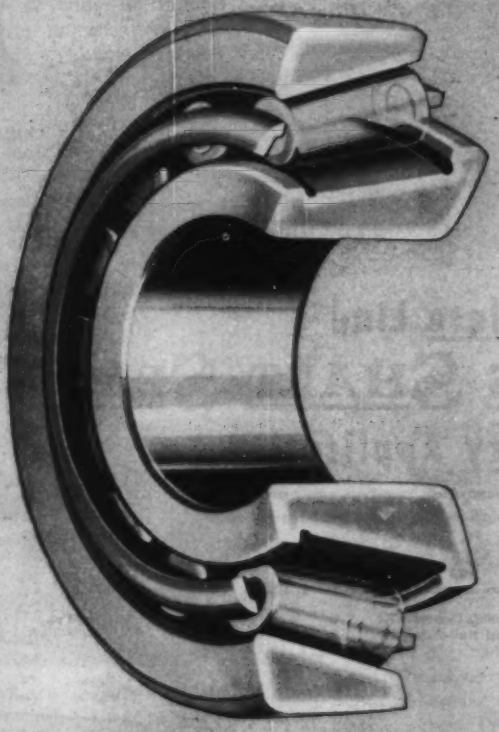
Circle 660 on page 19

Terminal Block

has compact terminal arrangement

Channel-mounted terminal block has 50 per cent more terminals in same space and greatly simplified assembly and modification. Blocks are available with 25-amp box-lug terminals or pressure wire con-

There's a BOWER TAPERED ROLLER BEARING engineered to fit your product



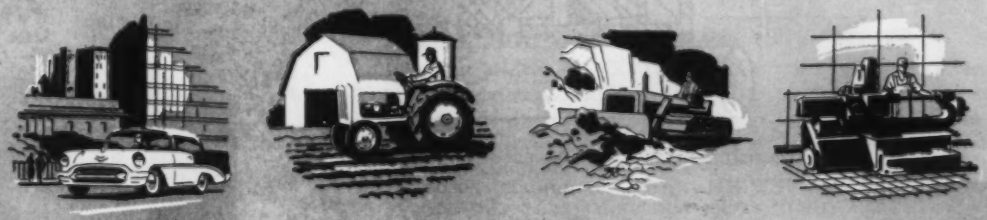
Types and sizes to fit a wide range of tapered bearing applications

There's no need to compromise with bearings! Whatever your product, if it uses tapered roller bearings, call in a Bower engineer for expert help on selecting the exact type and size you need.

Depending on your own particular needs, he'll make sure you get the exact size and type—selected from Bower's complete tapered line—engineered to assure maximum performance in your application.

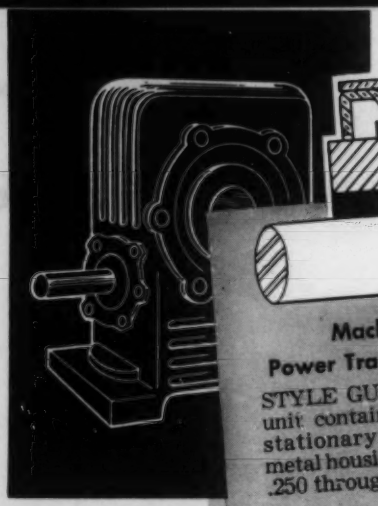
Most important of all, when you specify Bower tapered roller bearings for your product, you get all the advantages of advanced Spher-O-Honed design—less maintenance, longer life, smoother operation. Get the full facts on the *complete* Bower line.

Tapered, Straight and Journal Roller Bearings for every field of transportation and industry



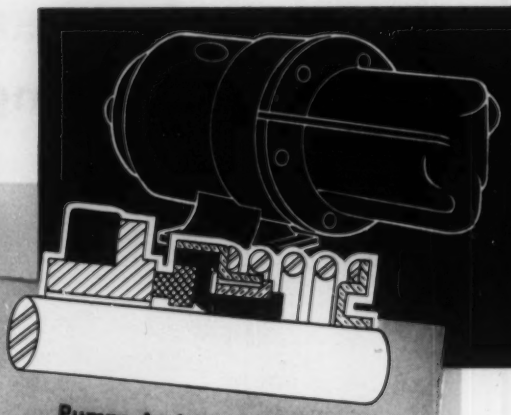
BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION • FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.



Machine Tools And Power Transmission Equipment

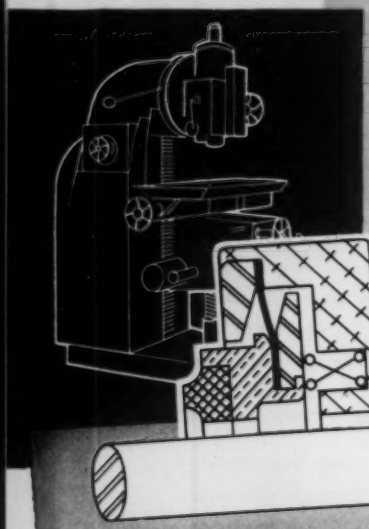
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

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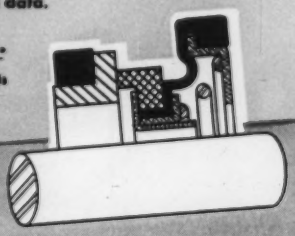
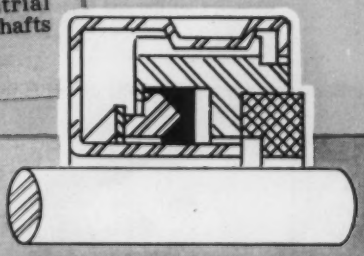


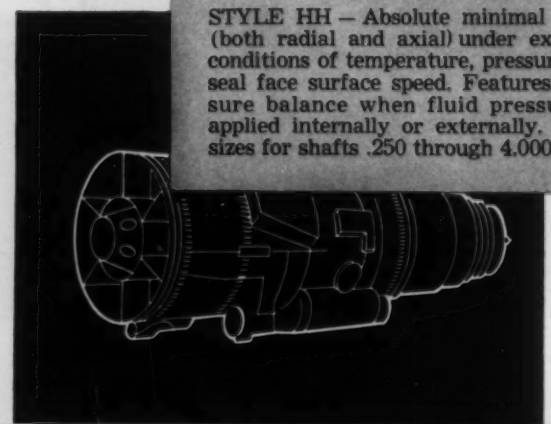
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



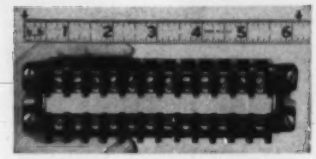
Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 471 on page 19

nectors, and 50-amp box-lug terminals. Channel mounting permits adding new terminals to existing



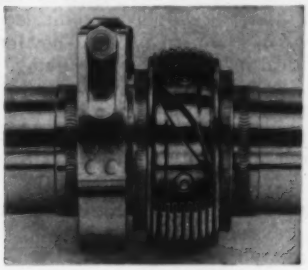
blocks at ends or middle with minimum disturbance of existing terminals. **Square D Co.**, 4041 N. Richards St., Milwaukee 2, Wis.

Circle 661 on page 19

Universal Duct Joint

absorbs axial and torsional forces

Marman MB11 universal joint meets severe flexure and vibration requirements of aircraft ducting systems and handles high volume of gases from −300 F to 500 F. Available in sizes from 2 to 4 in.,



unit allows angular deflection to 10 deg. Joint withstands burst test of 800 psig and life test of 600,000 cycles at 200 psig, 800 F, with 5 deg flexing. Unit is made of high-temperature, corrosion-resistant materials. **Marman Products Co. Inc.**, 11214 Exposition Blvd., West Los Angeles 64, Calif.

Circle 662 on page 19

Servoboard Differential

resolves different input speeds

Precision differential provides sum or difference of two shaft positions or speeds for guidance systems, analog computers, instruments, servo-mechanisms, motor drives, regulators and timers. Inputs are applied to end gears; output is taken from differential shaft. When

(*Continued on Page* 140)

speed cases through sealing machines

From 300 to 1300 cartons per hour flow through this Elliott Automatic Case Sealer. Each carton is folded, compressed and tightly glued. Different case sizes used in the food and fruit packaging industries are easily handled. Production rates are adjusted as required. And, case sealing is reduced to a simple, clean, one-man operation.

To insure such performance — continuous production at high or low speeds — CULLMAN chains and sprockets are used throughout. Short centered drives rotate the rollers. Long centered drives, with a cross-bar between them, feed the cases through the sealing machine. Both chain drives are synchronized. Here, they absorb overloads and prevent slippage; hence, equipment life is extended, operating and upkeep costs are reduced.

here's how chain drives can work for you...

On your products too, CULLMAN chains and sprockets can achieve similar advantages, help deliver top performance. Next time you are faced with a power transmission problem, write direct or call in a CULLMAN man. He will be glad to assist you — and recommend the right chain drive for your job.

For the full story on the Cullman power transmission line — roller chains, sprockets and flexible couplings, write today for catalog No. 51, or see your local Cullman Distributor.

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POWER TRANSMISSION
ROLLER CHAINS AND SPROCKETS

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CULLMAN WHEEL COMPANY, 1336 ALTGELD STREET, CHICAGO 14, ILLINOIS

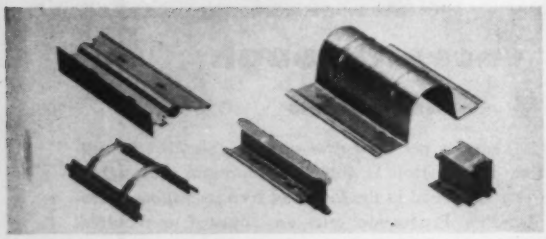
TWO METALS

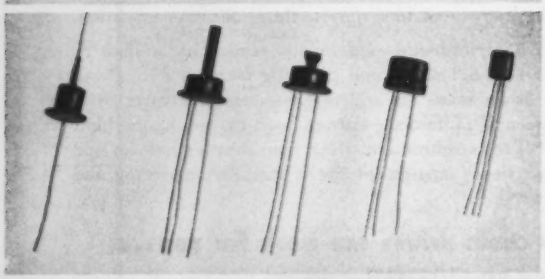
are often better than one...

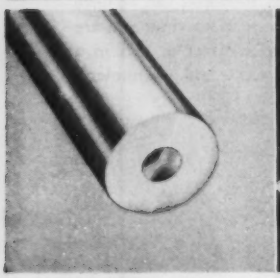
and

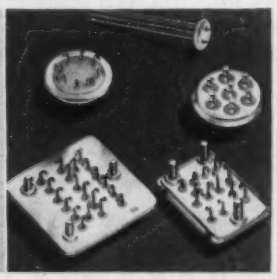
GENERAL PLATE *Clad metals*

for electronic uses are a case in point









Consider General Plate ALIRON®, ALNIFER®, and NIFER®, all preferred materials for vacuum tube plates. Offering improved performance with attractive cost savings, these General Plate Clad Metals are supplied in annealed coils ready to feed through your production tools. They form beautifully, conserving critical materials and producing more parts per pound. ALIRON and ALNIFER require no carbonizing — the matte finished aluminum blackens evenly during bombardment to provide a highly efficient radiating surface. For full details, write for Technical Data Bulletin 717C.

Or consider General Plate TIN CLAD NICKEL. Here's an improved material for transistor cradle supports. The layer of pure tin is unvarying in thickness and is bonded to a pure electronic grade nickel backing so completely that voids and contaminating inclusions are eliminated. This means perfect wetting during your transistor soldering operations — top transistor performance every time — lower soldering costs too! For full details, write for Technical Data Bulletin 708.

Or look to General Plate COPPER CORED 52 ALLOY WIRE for better glass-to-metal seals. With a 30% copper core you'll get up to three times the electrical and thermal conductivity over solid lead wires of the same size — or you can cut your solid lead wire sizes correspondingly, without reducing electrical ratings by using General Plate Copper Cored 52 Alloy Wire, and take a big step toward miniaturization in sealed terminal blocks and hermetic headers. For full details, write for Technical Data Bulletin 706.

To get the whole General Plate Clad Metal Story, write for our new general catalog, PR-700A, covering many other combinations in both base and precious clad metals — composite electrical contacts — TRUFLEX Thermostat Metals.

Metals & Controls Corporation

You can profit by using General Plate Clad Metals

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Here's the story of fatigue-proof steel bars

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Elevated Temperature Drawing

*a **new** material—made by*

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*a **new** combination of properties*

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Uniformity
Fatigue Resistance
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Dimensional Stability

Plus Accuracy, Smooth Finish, and Straightness

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Circle 474 on page 19

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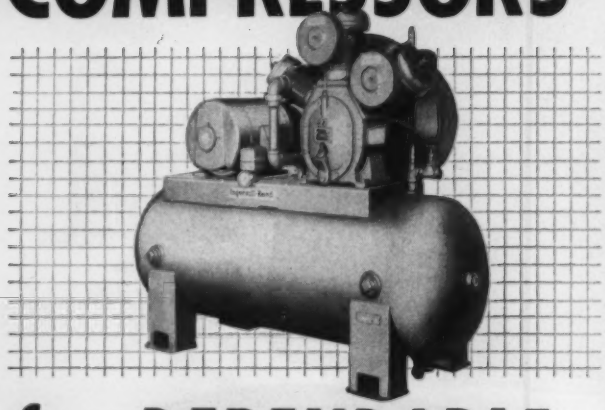
DESIGN WITH COMPACT

IR COMPRESSORS



...for DEPENDABLE, long-life EFFICIENCY

When important production equipment depends on air for operation, you'll breathe easier knowing that the best compressors are there with the air—whenever needed. Ingersoll-Rand Type 30 Compressors are designed and built to exacting standards that insure efficient and continuous service.

Rugged construction and low maintenance have characterized I-R Compressors for years—and for years Ingersoll-Rand has set the standard for economical compressor performance in every type of duty.

For your air-operated equipment, specify Ingersoll-Rand Type 30 Compressors. Choose *exactly* the unit you need from I-R's complete line of packaged air-cooled units from ½ through 20 horsepower. Write today for descriptive literature showing bare, baseplate mounted or complete receiver mounted units.

Packaged air-cooled compressors—½ through 20 horsepower. Other compressors to 6000 horsepower.

Ingersoll-Rand

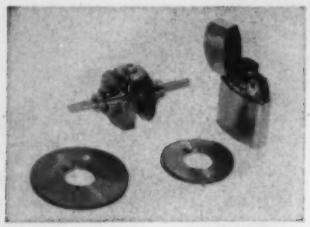
11 Broadway, New York 4, N.Y.

3-495

New Parts

(*Continued from Page* 137)

both gears are rotated in same direction, resulting output is half sum of inputs. When end gears rotate in different directions, out-



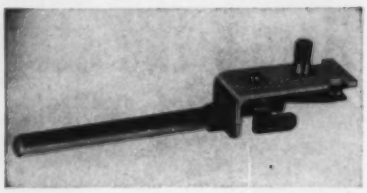
put is half of difference; direction of rotation depends upon rotation of lesser input. Ratios are 1:1 to 1:1.666. **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, N.Y.

Circle 663 on page 19

Probe Thermostat

for power-supply cord of appliances

Probe-type thermostat for appliance power-supply cord is for such applications as fry pans and deep

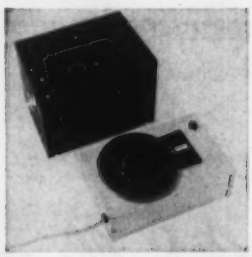


fryers. Thermostat is rated 1650 w at 115 v ac. Range is from open in low to 500 F in high. **Stevens Mfg. Co. Inc.,** Lexington, Ohio.

Circle 664 on page 19

Automatic Positioner

provides remote control or automatic selection



Model AS control unit provides automatic positioning control. An unusual application of bridge cir-

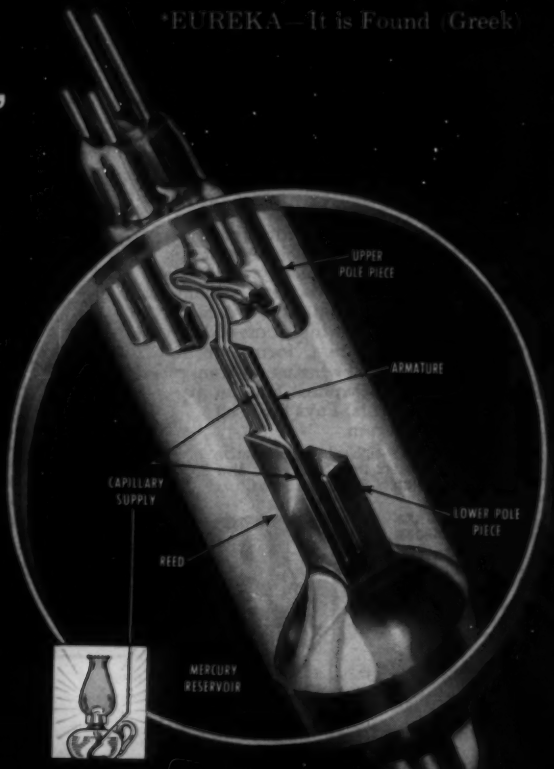
Circle 475 on page 19

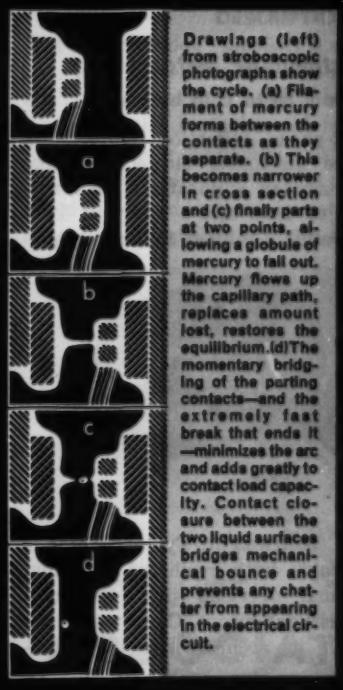
Circle 476 on page 19→

ΕΥΡΗΚΑ*

*EUREKA—It is Found (Greek)

INDUSTRY FINDS A "FOUNTAIN OF YOUTH" IN THIS SELF-REJUVENATING CLARE RELAY





Drawings (left) from stroboscopic photographs show the cycle. (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. Mercury flows up the capillary path, replaces amount lost, restores the equilibrium. (d) The momentary bridging of the parting contacts—and the extremely fast break that ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges mechanical bounce and prevents any chatter from appearing in the electrical circuit.

Ponce de Leon failed in his quest for a "fountain of youth," but modern design engineers find rejuvenation an accomplished fact in CLARE Mercury-wetted Contact Relays . . . capable of billions of operations.

Contacts of these relays are constantly renewed. By capillary action, like that of a lamp wick, a new film of mercury coats the contacts with every make and break.

The magnetic switch is sealed in a high-pressure hydrogen atmosphere in a glass capsule. Surrounded by the operating coil, the capsule is enclosed in a vacuum-tube-type steel envelope.

Unlike ordinary relay contacts, these contacts never wear out; never get dirty; never lock or weld; never get out of adjustment; never bounce.

Send for CLARE Engineering Bulletins No. 120 and 122. Address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Avenue, Toronto 17. Cable Address: CLARELAY.

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Provides synchronized printing and developing speed, with full stop and reverse control.

Electronic drive gives instant and continuously variable speed change.

Handles cut sheets or roll stock up to 44 in. wide in any length.

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Progressing with the Reproduction Industry Since 1937
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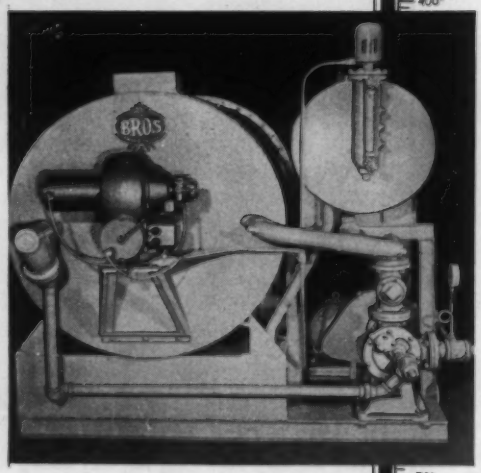
Circle 477 on page 19

HOW VIKINGS PUMP OIL UP TO 500° HOT



By use of two Vikings, a positive, constant flow of hot oil is pumped through this Bros hot oil heater, providing accurate control of the high temperature—up to 500°F.

Built by Wm. Bros Boiler and Mfg. Co., Minneapolis, Minn., the unit is widely used in highway construction, lumber and paper mills, paint plants, soap factories and many other industries.

You, too, will find Vikings ideal pumps for positive and smooth delivery of liquids. For information, write for Bulletin 57Sh.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U S A In Canada, it's "ROTO-KING" pumps

See our catalog in Sweets

Circle 478 on page 19

New Parts

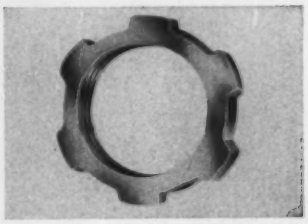
cuitry provides positioning accuracy of 0.5 per cent and repeatability of 0.25 per cent without use of vacuum tubes or photocells. Applications for unit include remote positioning of valves and dampers, remote instrumentation in conjunction with indicating instruments and as a control element in automatic selection equipment. **Wallson Associates Ltd.**, Newark, N. J.

Circle 665 on page 19

Conduit Locknuts

high-strength units are cadmium plated

Cold-formed, high-tensile steel conduit locknuts are available in all standard sizes up to 6 in. Nuts



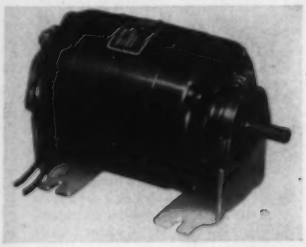
are cadmium plated and have much higher tensile strength than standard die-cast nuts. **Jacobson Nut Mfg. Corp.**, Box 177, Kenilworth, N. J.

Circle 666 on page 19

Fractional-HP Motor

for 1/30 to 1/15 hp loads

Split-phase induction motor, for office machines, blowers, pumps, and similar applications, has ratings of 1/20 and 1/15-hp at 1725 rpm and 1/30-hp at 1125 rpm. Com-

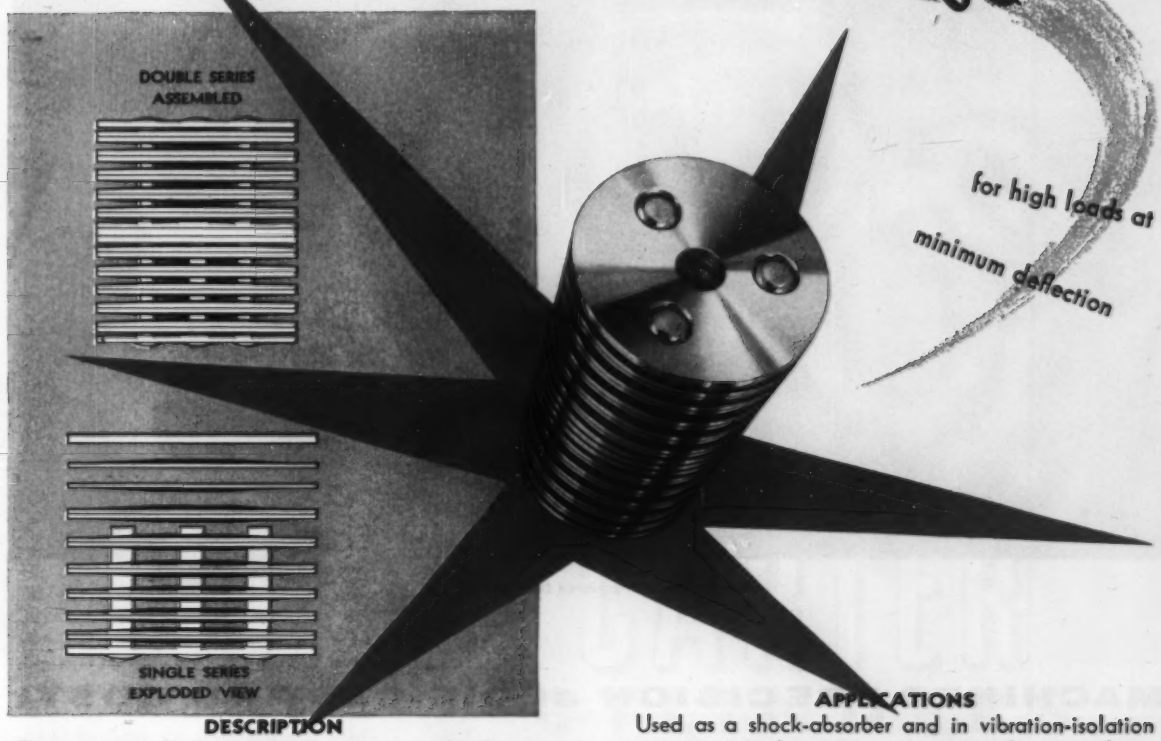


pact, lightweight, Type-U motor is available with resilient mounting, thermal overload protection and centrifugal cutout. Close tolerances result in accurate bearing align-

NEW COMPACT

Energy Cartridge

for high loads at minimum deflection



DESCRIPTION

This new cartridge* provides a compact stack of pre-assembled Belleville washers, a solid, one-piece unit—easier to handle and install than loose washers. The washers are held together with face plates and pins or rivets at or near the neutral axis. Washers may be assembled in series, parallel, and parallel-series according to space and load requirement. Eliminates manual hazard of assembling in wrong sequence at assembly point.

APPLICATIONS

Used as a shock-absorber and in vibration-isolation mountings; in die springs, automotive drives, machine-tool chuck and spindle drives, etc.; to exert constant pressure in cases of expansion due to temperature variations; fills need for a spring with constant load-deflection characteristics acting in compression.

For further information or specific application, consult engineers at any Division. Write for booklet — "Belleville Springs and Energy Cartridge."

*Reg. U.S. Pat. Off.

3708

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OHIO DIVISION, 1825 EAST FIRST ST. DAYTON, OHIO

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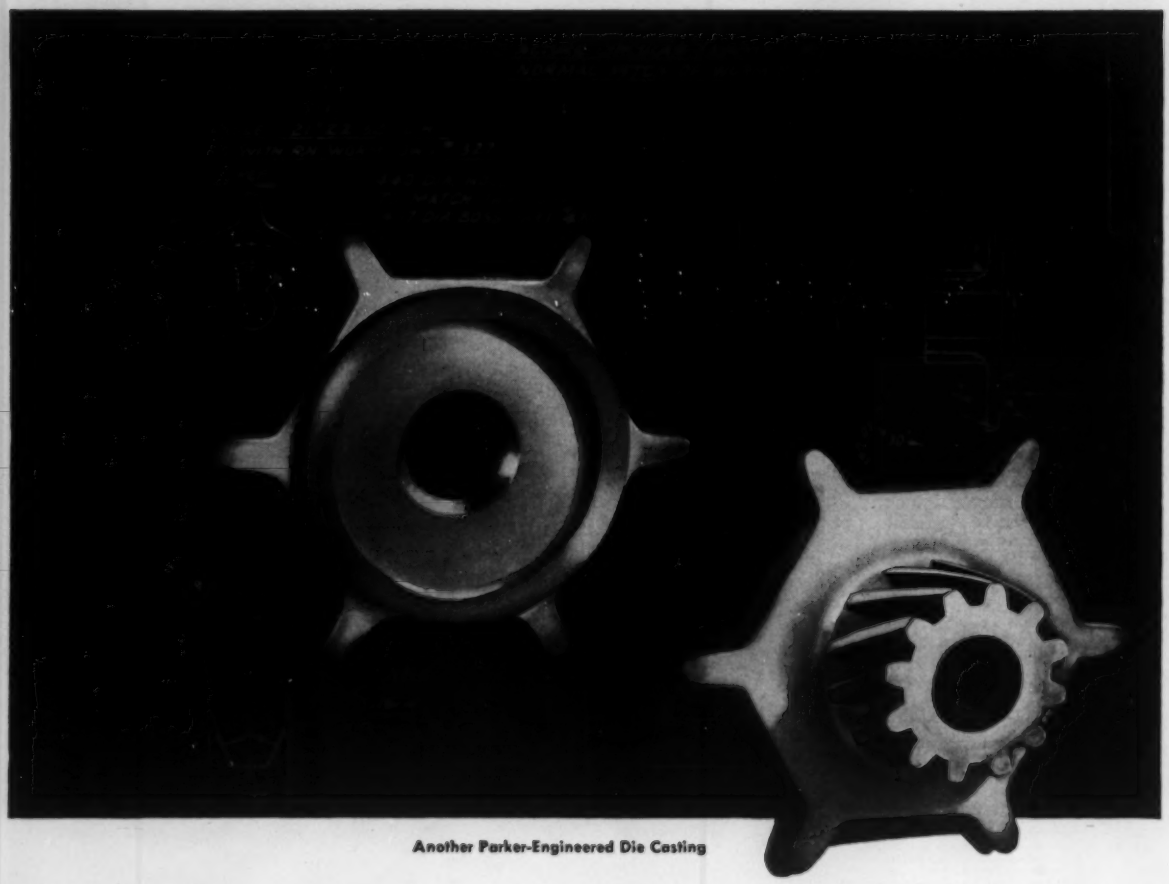

Another Parker-Engineered Die Casting

MACHINED PRECISION at DIE-CASTING COST!

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Produced complete in one operation . . . to extremely close tolerances . . . this helical gear part is yet another example of the way Parker-engineered die castings can save you money by eliminating costly tooling-up and machining operations on component parts. Combine this inherent cost advantage with exceptionally smooth as-cast finish, high density and good tensiles and you can see why Parker Die Castings—in zinc or aluminum—open up wide new possibilities to the design engineer.

Parker has been a leader in die-casting for 50 years—an old hand with new ideas. Take advantage of this skill. Just call the nearest Parker sales engineer or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

Circle 480 on page 19

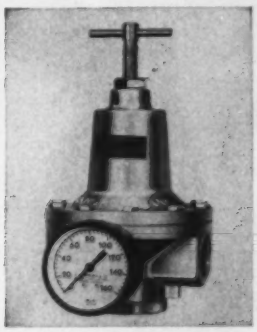
ment and uniform air gap, assuring quietness and efficiency. **Bodine Electric Co.**, 2254 W. Ohio St., Chicago 12, Ill.

Circle 667 on page 19

Pressure Regulators

have improved accuracy of pressure control

Relieving and nonrelieving type air-pressure regulators have precise control over entire operating range regardless of fluctuations in line pressure or variations of air flow. Features include large air passages,



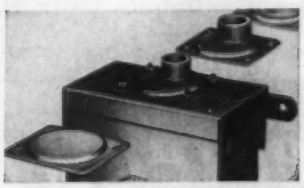
balanced valve construction, improved siphon-tube action, and greater effective diaphragm area. Units are for water, oil and noncorrosive gases. Pipe size range is ¼ to 1 in. **C. A. Norgren Co.**, 3400 S. Elati St., Englewood, Colo.

Circle 668 on page 19

Enclosure Hub

eliminates need for conduit or nipple offset

Interchangeable raintight hubs are suitable for enclosures for safety switches, circuit breakers, and fusible service equipment. Unit is



designed to eliminate need for conduit or nipple offsets when NEMA III enclosures are used and hub requirement is 2 in. or less. Hub has elongated slots for accurate

(*Continued on Page* 148)

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LET CARTER CARRY YOUR INVENTORY!

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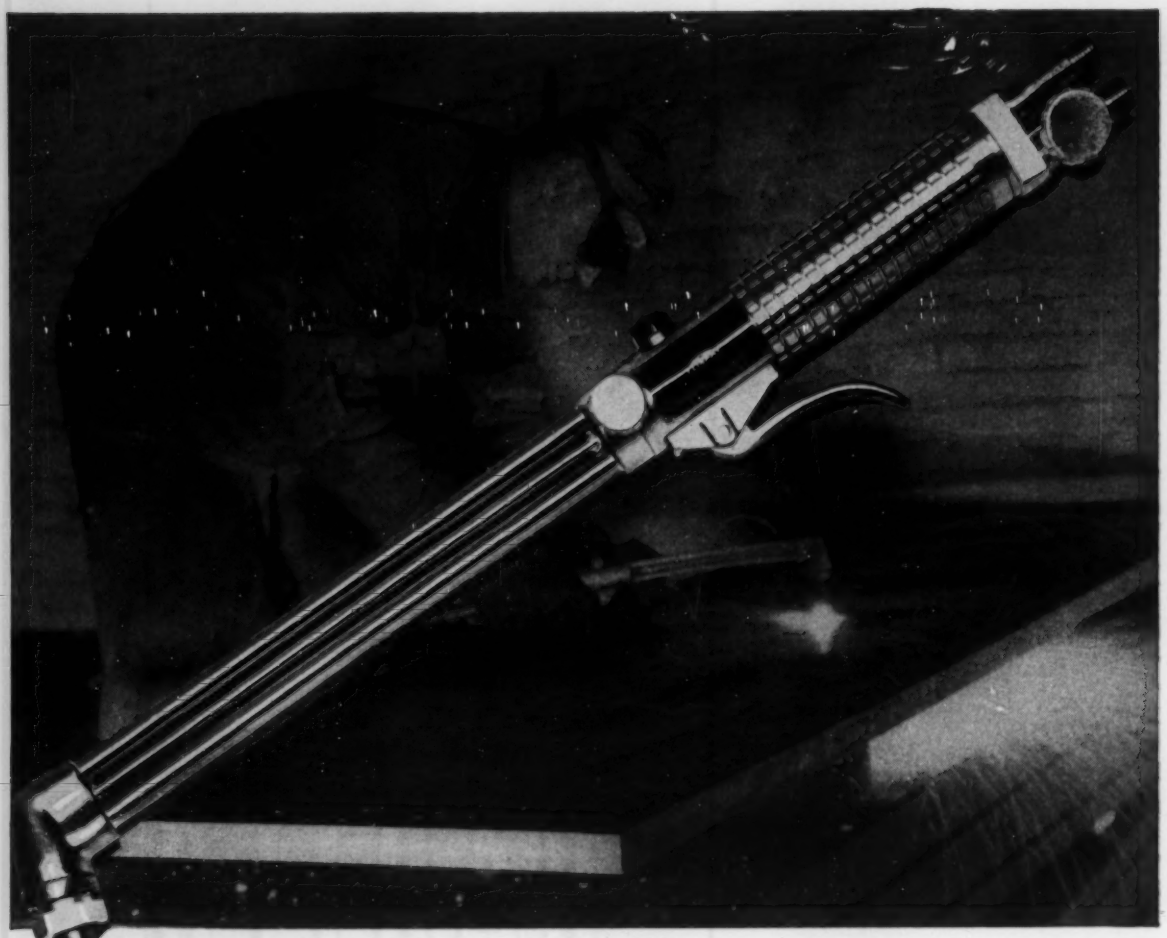
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 481 on page 19



Carpenter Stainless Tubing provides strength, rigidity, heat resistance in cutting torch

● The fuel gas and oxygen tubes in this oxy-acetylene cutting torch must be rigid, heat-resistant and have a high strength-weight ratio for long service and easy handling.

Carpenter Stainless Tubing meets every requirement for this torch, plus providing for easy tube assembly. The stainless tubing is cut to length and silver soldered to the head and body of the torch.

These and other inherent advantages of stainless tubing and pipe, plus the cost-saving difference made possible by Carpenter *quality*, can help you design, build or use improved parts and products.

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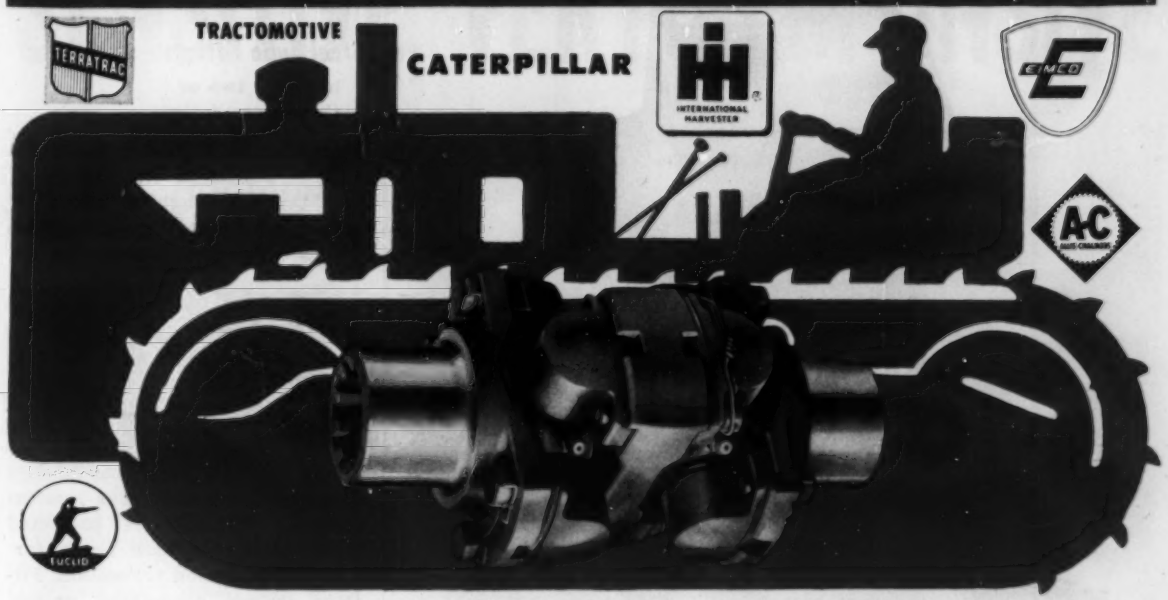
Carpenter

Stainless Tubing & Pipe

FLEXIBLE



Modern Crawler tractor design requires a F-L-E-X-I-B-L-E connection between the engine and transmission. MECHANICS Close-Coupled Type UNIVERSAL JOINTS not only provide for high angularity within cramped space but compensate for out-of-alignment conditions. The shocks and strains that crawler tractors encounter in heavy duty work often are so great that they temporarily twist the tractor frame. MECHANICS Close-Coupled Type UNIVERSAL JOINTS are designed to provide the F-L-E-X-I-B-I-L-I-T-Y needed to make efficient operation possible under such adverse conditions. MECHANICS exclusive KEY method of driving has the highest safety factor, transmits the most torque, and averts costly breakdowns that result from driving through bolts or screws that work loose. Let our engineers show you how these MECHANICS advantages will benefit your product.

MECHANICS UNIVERSAL JOINT DIVISION
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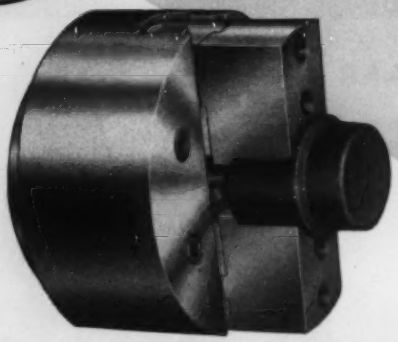
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Circle 483 on page 19

POWER CHUCKS



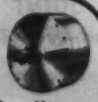
for more gripping power– higher production

Famous S-P cam and lever design holds the work tighter, permits cost cutting heavy feeds and multiple cuts. S-P cam and lever design also resists opening of jaws by centrifugal force or diminishing air pressure . . . an important safety factor. Balanced for high rpm.

S-P SELF-CENTERING CHUCKS are built in Universal American Standard models, sizes 6" – 8" – 10" – 12", and Serrated models in 8" – 10" – 12" sizes. Two or three jaws.

S-P COMPENSATING CHUCKS grip out-of-round work with equal pressure on each jaw. Available in 8" – 10" – 12" sizes, two and three jaw models, American Standard or Serrated.

S-P ROTATING CYLINDERS



Air and Hydraulic

Adequate stroke for long jaw travel of S-P Chucks. Balanced for high rpm on machine tools and other applications. Details in Catalog No. 105 (Air) and Bul. 201 (Hydraulic).

S-P Power Chucks are installed as original equipment by Bardons & Oliver, Cleveland Automatic, Cone Automatic, Ex-Cell-O, Jones & Lamson, Monarch, Warner & Swasey . . . and many others. Representatives in principal cities. Prompt deliveries. Send for catalog No. 105. The S-P Manufacturing Corporation, 30201 Aurora Rd., Solon, Ohio.

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THE S-P MANUFACTURING CORP.

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POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • AIR PISTONS, VALVES, ACCESSORIES

New Parts

(*Continued from Page* 145)

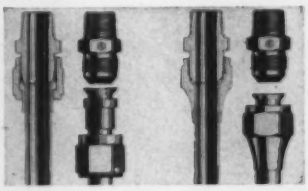
positioning. Reversal of hub plate permits forward and backward adjustment. Unit is available in five sizes from ¾-in. to 2 in. **Federal Pacific Electric Co.**, 50 Paris St., Newark 1, N. J.

Circle 669 on page 19

Steel Tube Fittings

in either two or three-piece design

Flare-Twin SAE 37-deg flared JIC steel tube fittings offer choice of two types throughout range of styles and sizes. Three-piece type with sleeve offers installation ad-



vantages and two-piece is less expensive. Fittings are protected with black phosphate finish for rust and corrosion prevention. Fittings include connectors, unions, elbows, and tees in size range of ⅛ in. to 2 in. **Weatherhead Co.**, Fort Wayne Div., 128 W. Washington, Fort Wayne, Ind.

Circle 670 on page 19

Self-Aligning Bushing

has extremely high thrust capacity

High thrust capacity is provided by design of a self-aligning bushing which has outer race split axially to permit insertion of ball. Bush-

ing is SAE 52100 steel, through hardened to Rockwell 60-63 C, precision ground on all surfaces. Bush-

(Advertisement)

DESIGNER'S FAVORITE SENSITIVE, VERY RESPONSIVE

Thermoswitch® Is Rugged, Adaptable, Heat Controller

ASHLAND, MASS. — Word emanating from here is that Fenwal Incorporated's THERMOSWITCH units are usually the best solution for a design engineer with temperature-control problems.

THERMOSWITCH thermal controls are adaptable, sensitive, responsive, small, tough, and accurate — and their price is right. They frequently replace controllers costing much more, and do a better job.

Their principle of operation is unique — and highly competitive in terms of every quality most design engineers would require. The unique principle is this: *the activating control element is a single-metal shell that expands or contracts instantaneously with temperature changes, making or breaking the totally-enclosed electrical contacts.*

Design engineers have put THERMOSWITCH units to work everywhere that temperature control is vital — in planes . . . factories . . . ships . . . hospitals . . . food-processing plants . . . homes . . . laboratories. The list of THERMOSWITCH applications is virtually endless. So is the list of physical ordeals the units have survived and the high performance standards they've met.

When tested alongside bulb-type and enclosed bi-metallic thermostats under identical conditions, THERMOSWITCH units have overwhelmed both with performances like these:

- reaction speed, four to nine times as fast;
- heat-responsive area, three to six times as large;
- heat-transfer path, only one-third to one-sixth as long;
- temperature differential, only one-tenth to one-nineteenth as great;
- vibration-sensitivity, only one-twelfth to one-eighteenth as great;
- shock-sensitivity, only one-tenth to one-eighteenth as great;

FENWAL THERMOSWITCH UNITS may solve your temperature control problems, too. Sensitive, tough, and accurate — they have been put to work by designers wherever temperature control is vital. Over 25,000 variations of the THERMOSWITCH unit are available. Write for THERMOSWITCH folder.

Added to these points of superiority are such demonstrable features as uniformity of sensitivity throughout the operating range, built-in temperature anticipation, enclosed tamper-proof assembly, direct radiant heat reception, and an operating range from −100°F. to 600°F.

Other ranges are available, too. The point at which a unit makes or breaks a circuit is determined by a set screw easily adjusted in the field.

There's a Fenwal sales engineer ready to help you apply THERMOSWITCH units to your particular heat control problems — ready with over 25,000 variations. Write Fenwal for his name and for complete specifications. **Fenwal Incorporated, 192 Pleasant Street, Ashland, Mass.**

Fenwal

CONTROLS TEMPERATURE . . . *PRECISELY*

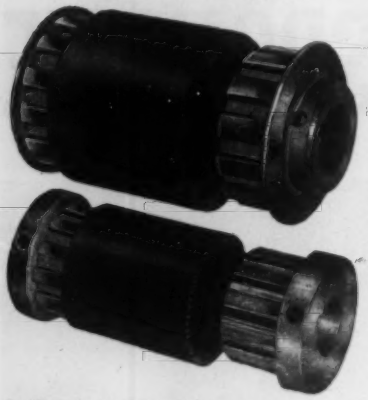
Circle 485 on page 19

NEW . . . NEW!

Gear-Grip

Flexible Coupling

The most revolutionary design advancement for integral H.P. in a century!

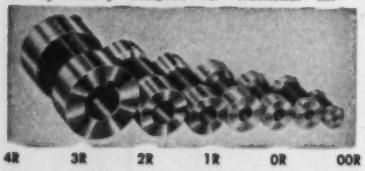


Positive power transmission of rated load. Gear teeth on end casting match special rubber tube section.

- Load ranges—2½ H.P. to 25 H.P.
- Shaft sizes—¾" to 1⅞".
- Specified lengths to design requirements.
- Prevents end thrust.

Dyna-Line . . .

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



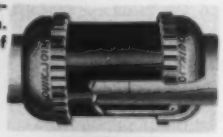
4R 3R 2R 1R 0R 00R

- True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.
- Lengths varied to design specifications in each series.
- Load ranges—1/15 to 1½ H.P.
- Shaft sizes—3/16" to ¾".

Quik-Joint

Steel Compression Pipe Fittings

- UL approved for hazardous fluids.
- Guaranteed for 2000 p.s.i.
- Allows 7° angular deflection.
- No threading of pipe required.



Write for Catalogs and Technical Bulletins.

Guardian
PRODUCTS CORP.
COUPLING DIVISION

DEPT. M-27, 1215 E. SECOND ST.
MICHIGAN CITY, INDIANA

Circle 486 on page 19

New Parts

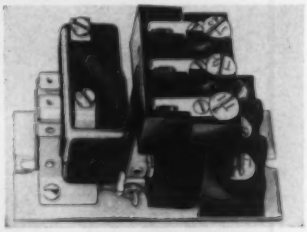
ings are for oscillating rather than rotating applications. Bore range is ½ to 4½ in.; thrust capacity range is 9,670 to 812,000 lb; radial capacity is 24,150 to 2,030,000 lb. **Roller Bearing Co. of America,** Sullivan Way, West Trenton, N. J.

Circle 671 on page 19

Magnetic Relay

requires no maintenance

Magnetic 20-amp relay, for fractional and integral-horsepower motors, can be used in most appliance and air-conditioning units. Minimum contact bounce and silver cadmium-oxide contacts eliminate



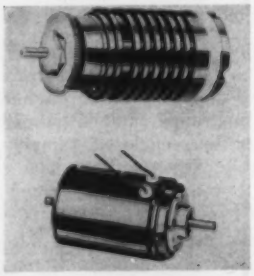
need for maintenance; relay will last life of appliance. Relay can handle solenoid valve and other control-circuit loads for motors. Rating is 20 amp, 300 v max. Available in 2, 3, or 4-pole, and all standard voltages. **Arrow-Hart & Hegeman Electric Co.,** 100 Hawthorn St., Hartford, Conn.

Circle 672 on page 19

Miniature Clutch

magnetic unit may be used as brake

Miniature magnetic clutch for electrical control of rotary mechanical functions, such as remote actuation of potentiometers and synchros,



may also be used for controlled loads or stops. Two lightweight, compact models are solenoid-op-

WE DON'T WANT JUST ANY MECHANICAL ENGINEER

BUT—

IF you are an M.E. or advanced graduate, well experienced in the design and development of intricate mechanisms—small gear, cam, lever devices and have a natural flair for these . . .

IF you know the processes by which such designs are put into quality, quantity production . . .

IF you are adept at getting your ideas across to others, and one of you is capable of supervising the work of other engineers . . .

THEN YOU'VE GOT A BRIGHT FUTURE AHEAD OF YOU AT

DELCO RADIO

. . . because Delco Radio offers you—

- A big-city salary and small-town advantages.
- Excellent opportunities for advancement.
- Modern work facilities.
- All the unusual employee benefits of General Motors.
- AND a wonderful community to live in, right in the heart of homey Indiana.

WRITE TO:

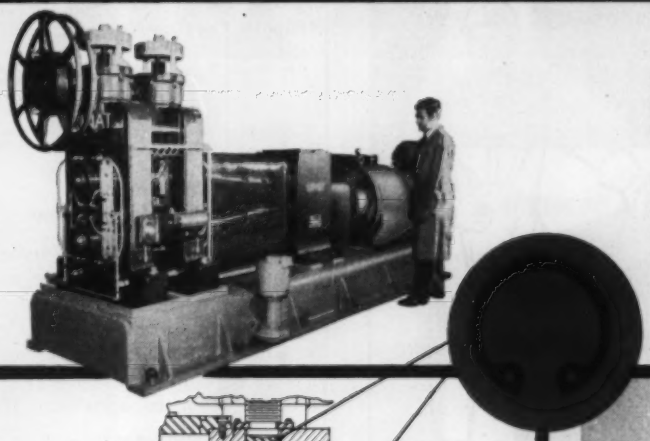
Personnel Director—A
Delco Radio Division

General Motors

Kokomo, Indiana

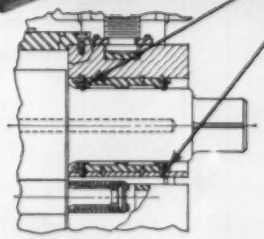
Circle 487 on page 19

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill



New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes...solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts...eliminate costly threading, other machining operations.

Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

WALDES

TRUARC®

RETAINING RINGS

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Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.

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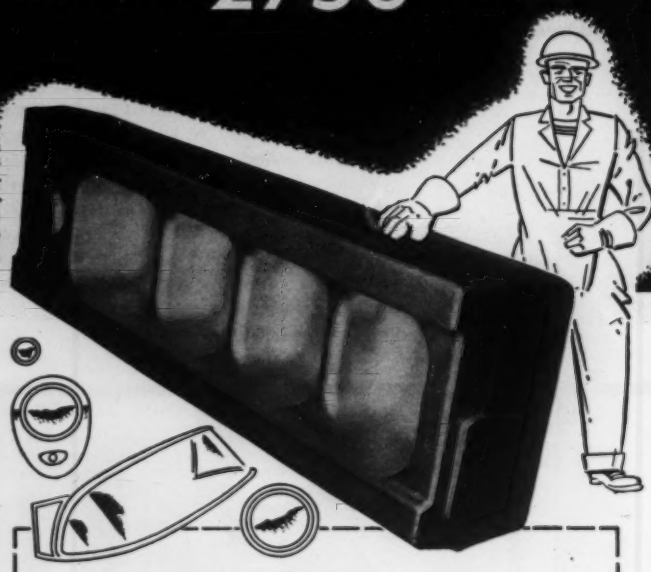
M D 029

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

THIS PARK CLOSED-DIE FORGING WEIGHS 2750 POUNDS



...and over 700 of them are helping break a glass production bottleneck

Called a "table feed rack", this steel closed-die forging was specially designed for the new glass making machinery required by the automobile industry.

Park's Complete Die-Sinking Facilities provided fast, efficient service.

And Park's Advanced Heat Treating Methods and metallurgical staff assured quality control throughout the production run.

Our sales engineers will show you how Park die-forgings can increase strength and safety—cut down size and machine time on your product requirements.

Die Forging Specialists Since 1907

THE PARK DROP FORGE CO.
773 EAST 79TH ST. • CLEVELAND 3, OHIO

CARBON, ALLOY AND STAINLESS STEEL CLOSED-DIE FORGINGS FROM 4 LBS. TO 5000 LBS.

New Parts

erated, dry-disk type, requiring no slip rings. Backlash-free units are designed for high cycling rates and operation at 24 or 48 v. Units provide 8 or 35 oz-in. combined braking and clutching torque. **Helipot Corp.**, Newport Beach, Calif.

Circle 673 on page 19

Hydraulic Pump

designed for automotive power-steering applications

Vane-type, belt-driven, oil-hydraulic pump designed for power steering is compact, lightweight unit featuring pressure-lubricated sleeve bearings. Unit has integral regenerative supercharged system to permit operation to speeds of 7150

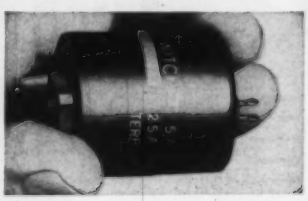
rpm. Capacity can be either 4 or 5 gpm at 1200 rpm. Supplemental flow control, integral with housing, provides flat delivery curve through normal speeds with lower delivery at high speeds where requirements are lower, resulting in less power loss and cooler operation. **Vickers Inc.**, 18353 West McNichols Rd., Detroit 32, Mich.

Circle 674 on page 19

Pressure Switches

have excellent over-pressure protection

Pressure switches that operate in any position have capsular element



to assure maximum vibration resistance. Units have excellent

Circle 489 on page 19

Now Available

through Local Distributors . . .

Perfectly Paired METAL HOSE* *and* Quick-Seal COUPLINGS

Titeflex hose and couplings solve some of industry's most vexing conveyance problems. Handle flow of organic and volatile liquids as well as gases, between moving or misaligned terminals, at wide extremes in temperatures and pressures. Also absorb vibratio· pulsation and shock. Couplings couple and u. ıple in ONE second . . . are leak-proof a ll operating pressures.

Hose sizes: 3/16" to 3" Coupling sizes: ¼" to 12"

**Other tough conveyance problems are solved with Titeflex flexible hose made of* TEFLON*—a Du Pont tetrafluoroethylene resin—in sizes of ¼" to 1¼"*

CALL YOUR LOCAL DISTRIBUTOR

Consult the yellow pages of your telephone directory

Your one source for both Hose and Couplings

Titeflex

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD 4, MASS.

when should you pay $13.00* a pound for TITANIUM?

The answer is *when its cost/life ratio makes titanium less costly than other metals*—as it often does. Look at it this way . . .

More Metal Per Pound—Titanium weighs only 56% as much as steel of the same strength. Where 50 pounds of steel is needed—28 pounds of titanium will do the job.

It's Final Cost That Counts—Fabricating takes the lion's share of production costs on most jobs. Considering material and fabricating costs together usually whittles down the titanium price differential to 2 or 3 to 1. And, most important . . .

Titanium Outlasts Most Metals—even those generally considered 'corrosion-resistant,' by 10, 20, even 50 times or more.

Added together, these facts often make titanium the most inexpensive material you can use. And only titanium can provide its exceptional combination of *light-weight, high-strength,* and *resistance to corrosion.* Ask a REM-CRU engineer to give you complete details about what titanium can do for you.

**The actual cost of titanium mill products varies with the grade, size and quantity ordered. The $13.00 figure is representative of today's prices for items used in commercial applications.*

Write Dept. MD-2 for the Rem-Cru Review—a free periodical presenting the latest data on titanium.

REM-CRU TITANIUM

World's Most Versatile Metal

MIDLAND, PENNSYLVANIA

Sales Offices: 3338 South Malt Avenue, Los Angeles 22, California • 4501 W. Cortland Street, Chicago 39, Illinois • 405 Lexington Avenue, New York 17, N. Y.

over-pressure protection plus that inherent in capsular element itself. Two ranges are available: 5 to 150 psi (regular), and 2 to 100 psi (miniature). Switches are single-pole double-throw, normally open or closed. Ratings are 5 or 10 amp at 30 v dc or 115 v ac. Ambient temperature range is −65 to 250F. **Bristol Co.,** 117 Bristol Rd., Waterbury 20, Conn.

Circle 675 on page 19

Plastic Tubing

'zips' around wires to form cable

Zippertubing reduces time and labor costs in lacing and typing operations for electrical harness assemblies. Tubing encloses, identifies and protects wiring. Pull-tab is detachable and tubing may be

unzipped and reused or permanently sealed. Sealed tubing withstands linear strength test of 30 lb per in. Size range is ½ to 4½ in. ID. Wall thicknesses are 0.020 and 0.040-in. **W. A. Plummer Mfg. Co.,** 752 S. San Pedro St., Los Angeles, Calif.

Circle 676 on page 19

Variable Resistor

unit features low noise level

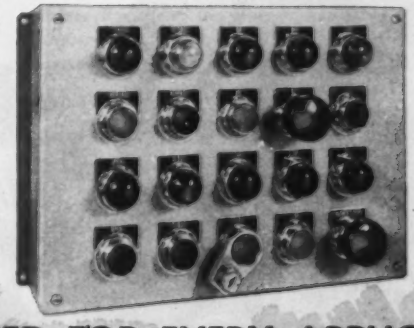
Type H, 5-watt, molded variable resistor has solid-molded resistance element to provide long life and low noise level. Resistor has no metal-to-metal electrical contact. Molded concentric collector ring and carbon brushes bridge collector and resistor rings. Control has maximum working voltage of 750 v dc; resistance range is 50 ohm to 2 megohms; temperature range is −55 to 120 C; operating life is

(*Continued on Page* 158)

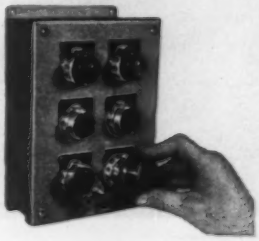
INTRODUCING THE New

FURNAS ELECTRIC

Oil Tight PUSH BUTTONS



DESIGNED FOR EVERY APPLICATION



Now for the first time, because of standardization and interchangeability, more combinations of Oil Tight push buttons are available with fewer parts. As a result, Furnas Electric design and research again lead the field, this time with the finest oil tight push buttons available.

When you specify Furnas Electric, you get one standard contact block. No rights or lefts—no special units for horizontal or vertical mounting.

Accessories (key lock, mushroom head or lever) are mounted directly on all standard operators. Operators need not be modified or removed from panels.

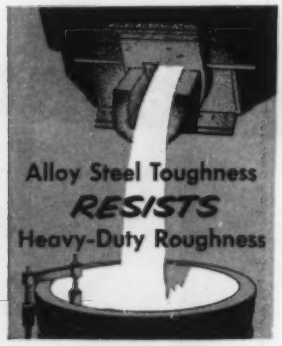
For full information on oil tight or general purpose push buttons, selector switches or pilot lights, write today for Catalog 5606. Furnas Electric Company, 1045 McKee Street, Batavia, Illinois.

A16

FURNAS

FURNAS ELECTRIC COMPANY

BATAVIA, ILLINOIS



DRIVE AXLE

Model "660" Motor Grader is built by Adams Division, LeTourneau-Westinghouse Company, Indianapolis, Ind.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

DESIGNED FROM ALLOY STEEL

Shrugs Off Fatigue, Terrific Torque, High Impact Load

Motor graders built by Adams Division of LeTourneau-Westinghouse Company are known throughout the world for quality and dependability.

A good example of the company's constant effort to improve this quality and dependability can be found in the grader's full-floating, two-section drive axle—considered to be the most vulnerable part in the entire unit. It is subjected to terrific torque from an eight-speed, constant-mesh transmission. Impact load is often extreme.

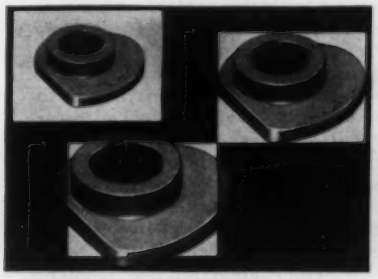
Company engineers and metallurgists spent thousands of hours on research and field testing of all types of steels to find one that would reduce ultimate fatigue in the axle to an absolute minimum.

They eventually settled on Republic Hot Rolled 4340 Alloy Steel. This fine steel not only resists fatigue, but also is able to take a high torque without a permanent set. Fatigue failure is now practically non-existent.

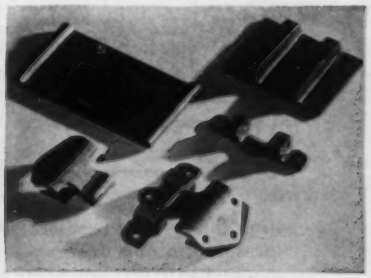
Alloy steels provide an outstanding combination of qualities essential to designing smaller sections to move or carry heavier loads with no sacrifice of strength or safety. They resist fatigue, shock and stress. Respond uniformly to heat treatment, producing hard, wear-resistant surfaces around tough cores. This tough, integral structure provides greater strength with minimum weight.

Specify Republic Alloy Steels for your jobs where strength and toughness must resist heavy-duty roughness. We offer you the services of our experienced field metallurgists to help you get the most from these versatile steels at the lowest possible cost. There's no obligation. Just mail the coupon.

COMPLETE DESIGN, engineering and fabricating facilities go to work for you as an extension of your plant when you have your stamped and drawn parts fabricated by Republic's Pressed Steel Division. This truck shaft bracket is one example of a wide variety of steel parts mass produced to specification at the lowest possible cost. Send coupon for Booklet Adv. 681.



DIE AND PART DESIGN PROBLEMS are reduced by 3 new grades of Republic Iron Powder with *Controlled Dimensional Factor.* In the presence of copper, these powders—depending on type—can be made to grow, remain stable, or shrink, within acceptable limits. Complete information on Type "G" for growth, Type "N" for normal, Type "S" for shrinkage are contained in Booklet Adv. 763. Write for it.



LIMITLESS FLEXIBILITY IN DESIGN is provided by Republic Special Sections. They simplify built-up, interlocking or associated parts. Machining time and costs are reduced to a minimum because the sections are preformed to the predominating cross section of the part. Available hot rolled or cold drawn in all grades of carbon, alloy and stainless steel. Send coupon for more information.

STEEL

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☐ Have an Alloy Steel Metallurgist call.

Send more information on:
☐ Stampings (Booklet Adv. 681) ☐ Iron Powder (Booklet Adv. 763)
☐ Special Sections

Name_____ Title_____

Company_____

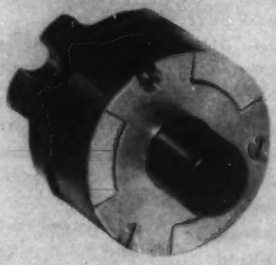
Address_____

City_____ Zone____ State_____

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE MOTOR PROTECTOR

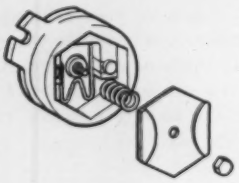
RBM

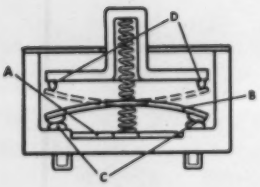
AUTOMATIC RESET—#91300, #91400



MANUAL RESET—#92300, #91400

A PRODUCT OF RBM DIVISION OF ESSEX WIRE CORP. LOGANSPORT, IND.





After years of development by RBM Division of Essex Wire Corp., and now in volume production, this bimetal motor over-load protector provides overload protection for split phase or capacitor motors such as are used in many household appliances. It may also be used with 110/220 volt motors of heavier capacity. The disc-type element is sensitive so as to give instant response to locked rotor current, yet carry starting surges and protect against running over-loads. The calibration to trip at 105° (also 120°) allows for ambient compensation for varying temperatures within the motor. The box shape of the terminals prevents soldering spatter and the double break contact provides long contact life. The snap-action disc element is fabricated from Chace Thermostatic Bimetal.

Here's how the manual reset protector works: The heater wire (A) carries a normal load but is heated by locked rotor currents or running overload currents. The heater in turn heats the thermostatic bimetal disc element (B) until at the calibrated temperature it snaps into the reverse shape, opening the contact points (C); when the reset plunger is depressed after correction of the failure, the two buttons (D) contact the bimetal element, forcing it to snap back into its original shape with contacts closed.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

IT RUNS WITH THE HEAT

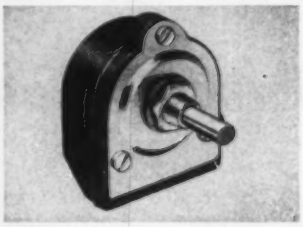
W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 494 on page 19

New Parts

(*Continued from Page* 155)

100,000 cycles or more. Unit has screw or bayonet terminals or



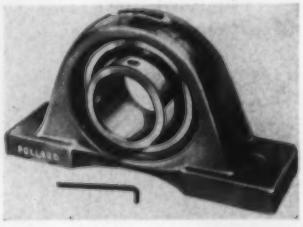
solder lugs. **Allen-Bradley Co.**, 136 W. Greenfield Ave., Milwaukee 4, Wis.

Circle 677 on page 19

Pillow Block

is prelubricated and permanently sealed

Pillow block is available in normal and medium duty series in bore sizes from ½ to 4 in. All units are permanently lubricated and sealed,



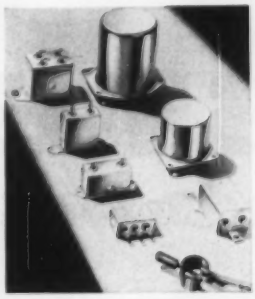
eliminating lubrication during service. Units are self-aligning and self-sealing. **Rockwood Pulley Mfg. Co.**, 20 Crosby St., New York 13, N. Y.

Circle 678 on page 19

Miniaturized RF Filters

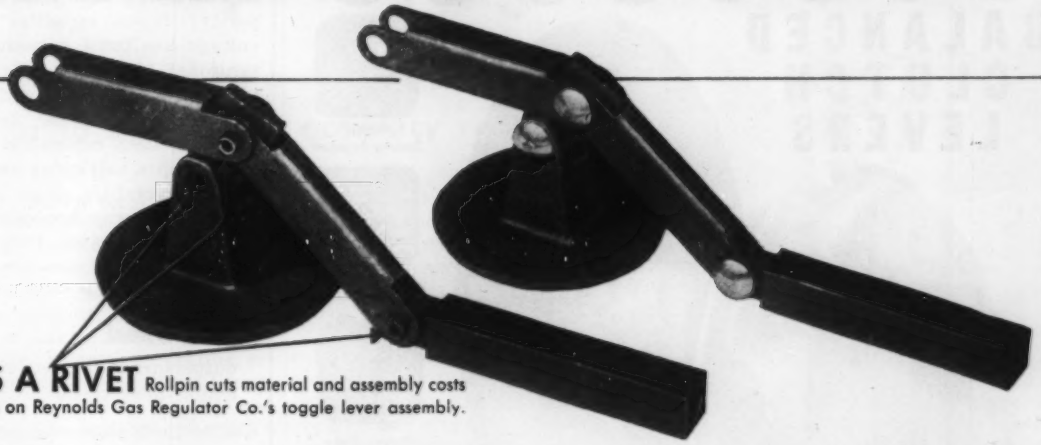
have high efficiency

Miniaturized, highly efficient radio-frequency filters and starting ca-

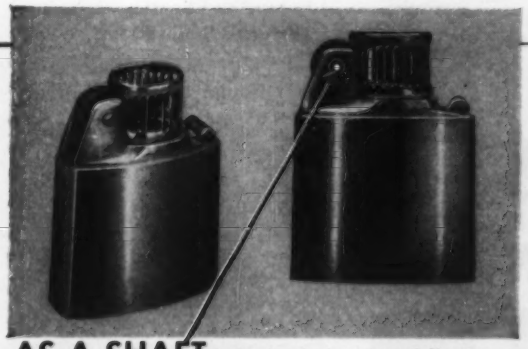


pacitors meet all applicable military

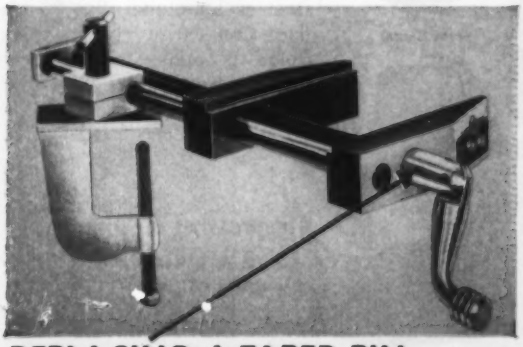
Three typical Rollpin cost reductions



AS A RIVET Rollpin cuts material and assembly costs 25% on Reynolds Gas Regulator Co.'s toggle lever assembly.



AS A SHAFT before and after shot of this Ronson lighter shows how Rollpin made savings of 1½¢ per unit in assembly of spark wheel.



REPLACING A TAPER PIN Rollpin saves 24¢ labor cost on each of American Machine and Foundry's MITY-7-VISES. Eliminates tool cost caused by breakage of small taper reamers.

ESNA® TRADE MARK

ROLLPIN TRADEMARK

Where can you use this simple fastener?

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your production and maintenance costs as it does in every class of industry. Rollpin is a slotted tubular steel pin with chamfered ends that drives easily into standard holes, compressing as driven. Its spring action locks it in place—withstanding impact loading, stress reversals and severe vibration. No threading, peening or precision drilling needed. Rollpin is readily removable and can be re-used in the same hole.

ELASTIC STOP NUT CORPORATION OF AMERICA

MAIL COUPON FOR DESIGN INFORMATION

Elastic Stop Nut Corporation of America
Dept. R38-24, 2330 Vauxhall Road, Union, N. J.

Please send the following fastener information:

☐ Rollpin samples
☐ Rollpin bulletin
☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

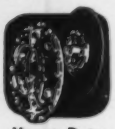
Street_____ Zone___ State_____

ROCKFORD

BALANCED CLUTCH LEVERS

Small Spring Loaded

Automotive Spring Loaded



Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

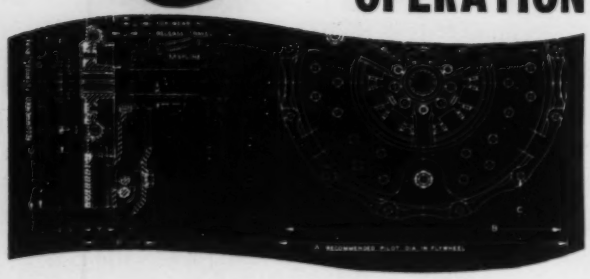
Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

INSURE EFFICIENT OPERATION



The release levers in ROCKFORD clutches have been newly designed and are accurately balanced—so necessary in present day *high-speed, high-torque* engines. This is just one of several advantages ROCKFORD equipped motor vehicles feature in their late models.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ENGINEERING B-W PRODUCTION

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

New Parts

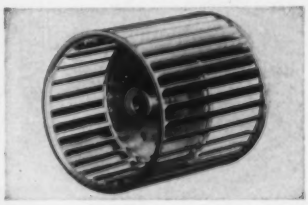
standards. Units have high capacity; 2½-oz capacitor at triple voltage has twice capacity of conventional 10-oz unit. Vacuum impregnated with resin and hermetically sealed in steel cans, units have excellent resistance to vibration, fungus, salt spray and humidity. Temperature range is −65 to 300 F. **Airborne Accessories Corp.**, 1414 Chestnut Ave., Hillside, N. J.

Circle 679 on page 19

Blower Wheel

outperforms double-width double-inlet types

Center-Lock blower wheel, for residential and commercial air conditioning and heating equipment, outperforms double-width, double-inlet types at lower unit cost. Center disc is dovetailed into blades with



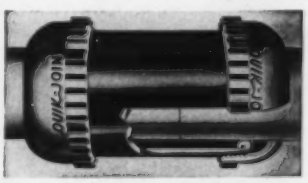
compression fit and tightens during rotation. Wheel is 6 5/16 in. diam by 5 13/16 in. wide. Impeller, of steel or aluminum, has 36 blades; bore sizes range from ⅜ to ¾-in.; finish is plain, lacquer or zinc-plated. **Torrington Mfg. Co.**, Air Impeller Div., 100 Franklin St., Torrington, Conn.

Circle 680 on page 19

Compression Coupling

joins nonthreaded lengths of pipe

Steel compression-type coupling eliminates cutting threads in steel pipe. Joint is made up by slipping



coupling over unthreaded ends of pipe and tightening with pipe wrench. Close tolerance pipe is unnecessary, and corrosion of ex-

Circle 496 on page 19

(Advertisement)

Tips on specifying timer accuracy

Facts you should be aware of when selecting a timer to meet your accuracy requirements

The application for a timer generally determines the kind and degree of accuracy needed.

If frequent changes are made in the timed interval, setting accuracy is most important. If a machine operation or process occurs again and again at the same timer setting, repeat accuracy is the critical factor. If a timer is factory set for, and operates continuously at, one specific interval, inherent timer accuracy is most important.

Each of these three major types of timer accuracy — inherent, setting, and repeat — calls for different design and manufacturing techniques:

INHERENT ACCURACY

A major factor limiting inherent accuracy is the drive motor. This must (1) be quick starting, (2) be free from coasting, and (3) operate only at synchronous speed. Permanent-magnet synchronous motors meet these requirements better than ordinary clock-type hysteresis motors.

Clutching on a high-speed shaft, close to the drive motor, also increases inherent timer accuracy. High-speed clutching — though more complex and costly than low-speed — should be used on timers in which high accuracy is paramount.

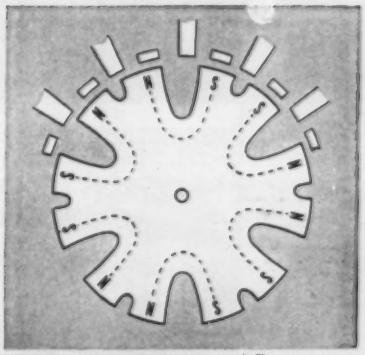
SETTING ACCURACY

Length of dial scale, scale divisions, style of pointers, parallax and distortion due to cover glass, and skill of operators are obvious influences on setting occuracy.

Setting may be of either the friction or vernier (or worm) type. The latter provides good setting accuracies, but lacks the speed and convenience of the friction method. Human errors can often be completely eliminated by use of a factory-set timer.

REPEAT ACCURACY

Shock of operation of a fast reset mechanism — or shock from other causes — can change the timer setting, resulting in inaccurate repeat cycles. This is most likely when the reset and setting mechanisms are combined for reasons of cost. However, by careful design, speed of reset and resistance to shock can be optimized to give the best repeat accuracy.



PERMANENT-MAGNET rotor of Cramer motor (shown here schematically) reaches synchronous speed within two cycles (0.033 sec. at 60 cps) after field is excited, does not coast after power is removed. Most powerful and accurate timing motor available for its size and price.

TECHNICAL HELP AVAILABLE

Cramer field engineers have the answers to most accuracy and other timing problems at their fingertips. They can tell you about Cramer timers with accuracies ranging from 2% to 1/100th of 1% overall. And they'll be glad to discuss your special requirements with you. Get in touch with your local Cramer representative today or write us direct. The Cramer Controls Corporation, Box 6, Centerbrook, Connecticut. 6.11

FOUR WAYS TO SOLVE YOUR TIMING PROBLEMS

NEW TYPE 241 AUTOMATIC RESET INTERVAL TIMER, with full-scale repeat accuracy of ± 1/4 of 1%. Convenient pushbutton start, automatic and immediate reset for electrically operated equipment. Fully described in Bulletin PB-241.

NEW TYPE 412 TIME DELAY RELAY. Positive action ratchet clutch. Repeat accuracy of ± 1/4 of 1%. Introduces timed delay interval between operation of control circuit and load circuit. Ranges: 6 sec. to 24 hrs. Bulletin PB-311.

TYPE 690 TIME TOTALIZER has ± 0.01% accuracy. Totalizes in 1/100th increments to 60 sec. or 60 min. High-speed electro-mechanical clutching. An electrical stop clock for research or production. A-c or d-c models. Bulletin PB-610.

HIGH-TORQUE CRAMER MOTOR, truly synchronous; instant start, stop. 300 speeds, various output shafts available. Torque: 30 in.-oz. at 1 rpm. Permanently lubricated, mounts in any position, UL approved. Bulletin PB-110A.

TALK IT OVER WITH CRAMER

CRAMER CONTROLS
CORPORATION

Circle 497 on page 19

CHOICE OF BUILT-IN VALVES GIVES CONTROL FLEXIBILITY

SINGLE AIR CONNECTION SIMPLIFIES INSTALLATION

RUGGED CONSTRUCTION ASSURES LONG LIFE

125 BELLOWS SALES AND SERVICE FIELD ENGINEERS

■ There are one or more Bellows Field Engineers in every industrial area of the United States and Canada. They will be happy to work with you in applying "Controlled-Air-Power" to your machine designs. They are listed in their local phone directories under "The Bellows Co."

J758-B

Four reasons why THE BELLOWS AIR MOTOR stands first with design engineers

In designing for air cylinder operation the engineer wants first of all sure, positive control, easily interlocked to related machine movements. **He has it in The Bellows Air Motor.**

He wants simple installation, uncomplicated by cumbersome piping. **He has it in The Bellows Air Motor.**

He wants rugged construction — an air cylinder that will stand up day in and day out with minimum requirements for service and repairs. **He has it in The Bellows Air Motor.**

But he also wants the knowledge, if service should ever be needed, that it is quickly available wherever his machine may go. **He has it in The Bellows Air Motor.**

The Bellows Co.

AKRON 9, OHIO

This free booklet offers interesting data for the design engineer. Write for it today. Address Dept, MD-257. Ask for Bulletin BM-25. The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd.

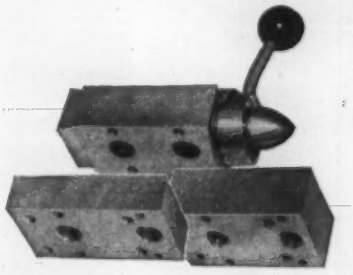
posed threads is eliminated. Coupling joins pipes with angular misalignment up to 7 deg. Unit withstands severe blows and shocks and pressures to 2000 psi. It may be used in lines carrying hazardous fluids. **Guardian Products Corp.**, 1215 E. Second St., Michigan City, Ind.

Circle 681 on page 19

Flow Regulator

for hydraulic manifold mounting

Adjustable flow regulator is designed for manifold mounting. Subplate kits have built-in check valve for free reverse flow. Minimum to maximum flow adjustment is ob-



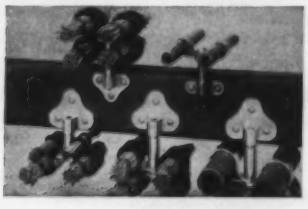
tained by 180 deg movement of control handle. Anodized aluminum unit weighs 5 lb. Four sizes provide maximum flow from 12 to 20 gpm; ports are ½-in. NPT. **Waterman Engineering Co.**, 725 Guster Ave., Evanston, Ill.

Circle 682 on page 19

Mounting Brackets

one-piece units cut installation cost

Aluminum mounting brackets for attaching hydraulic tubing, plumbing, insulation blankets and heater ducts in aircraft, cut installation



cost by eliminating conventional brackets, clips and tubing spacers. Self-locking thread insert provides

(*Continued on Page* 166)

Single frame from a high speed movie of an imploding television picture tube—a critical instant seen in relation to what preceded and followed during a spread-out fraction of a second.

Ever see a really high speed movie?

It's something to see—a one-second swipe of a cutting tool spread out to three minutes on the screen! Seeing a cam that is really turning at 500 RPM (and behaving that way) as though it were turning at 3 RPM! Studying the action of explosions, welding bead deposition, forging . . . all slowed as much as 200 times from normal.

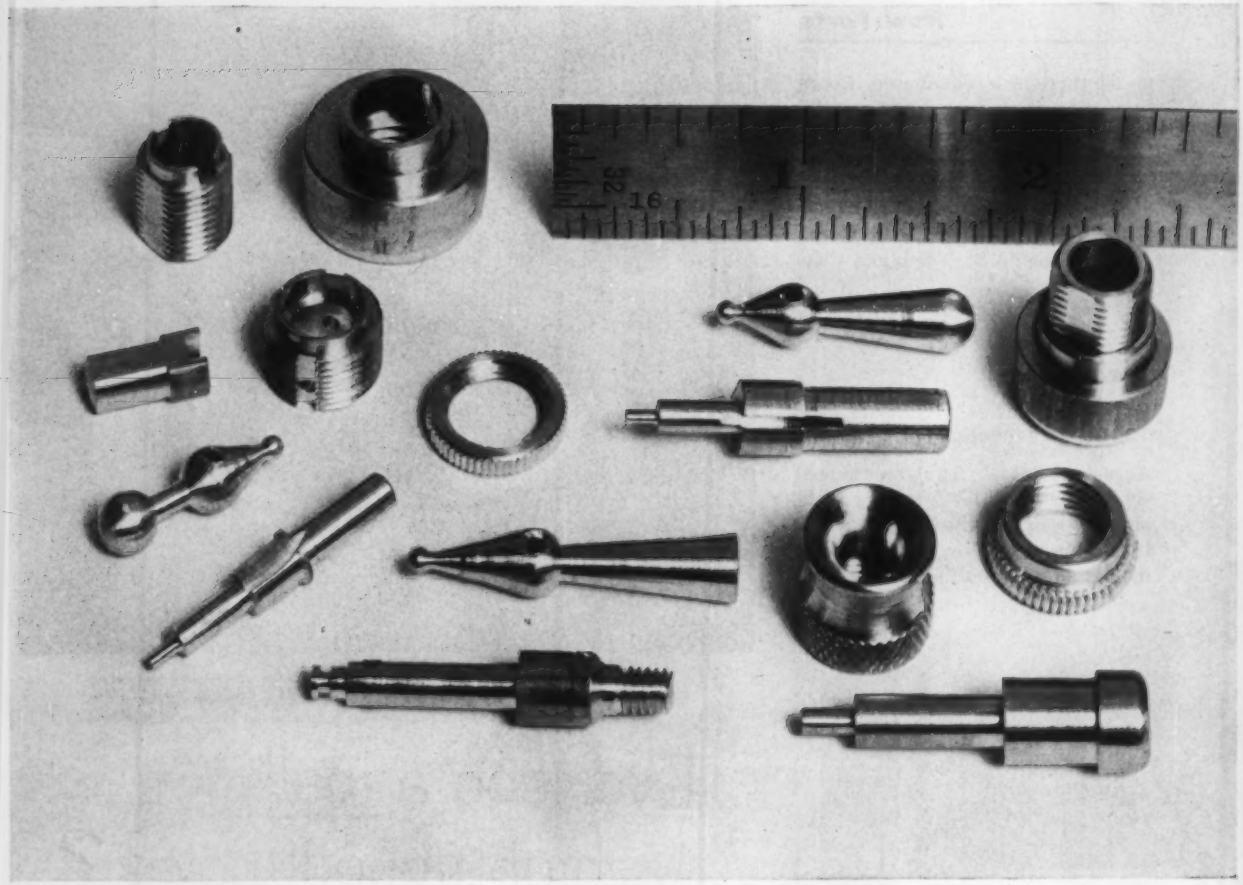
We've put together a movie on the Kodak High Speed Camera that will show you what high speed movies can do. It will also give you some ideas on how you might put high speed movies to work solving your own design, production, and performance problems that involve high speed mechanical action or fluid flow. To arrange for a showing to company groups of the 16mm sound movie, "Magnifying Time," write:

EASTMAN KODAK COMPANY, Rochester 4, N.Y.

the Kodak HIGH SPEED Camera

Kodak

Circle 499 on page 19



Typical parts machined by Leviton Manufacturing Company from Alcoa Aluminum Screw Machine Stock

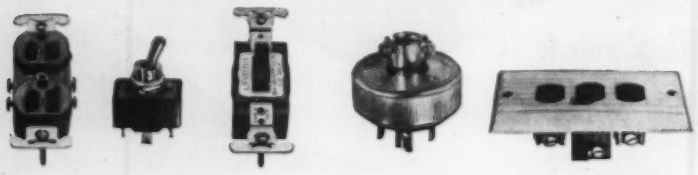
WHEN LEVITON MAKES A SWITCH, THEY USE ALCOA ALUMINUM SCREW MACHINE STOCK

Leviton Manufacturing Company first substituted aluminum for scarcer materials. Today, new parts are designed first for aluminum, and the other materials are viewed as substitutes.

For over thirty years, Leviton has specialized in the manufacture of fine electrical wiring devices for residential, commercial and industrial use. Today the company is the largest in its field and operates a huge main plant in Brooklyn, New York. Other plants are at Hillsgrove, Rhode Island; Montreal, Canada; Chicago and Los Angeles, with sales offices in all major cities of the United States and Canada.

Whether you make parts for the electrical industry, like Leviton, or market your products elsewhere, you'll find you can't beat Alcoa® Aluminum Screw Machine Stock for quality and economy. Cutting speeds as high as 1,000 feet per minute are not uncommon. Aluminum resists corrosion, offers excellent heat and electrical conductivity. Its light weight gives you up to three times as many parts per pound.

Alcoa wants to help you profit from aluminum screw machine stock's many advantages. Just call your nearby Alcoa sales office, listed under "Aluminum" in your phone book. Aluminum Company of America, 873-B Alcoa Building, Pittsburgh 19, Pennsylvania.



LEVITON

IN MANAGEMENT

Bernard Leviton, Executive Vice President and spokesman for the Standards Committee says, "Alcoa has been one of our suppliers since 1941. Since then, we have had a steady progression of changes to aluminum. Ours is a high-volume, high-production business. In any case where we've had a problem—whether materials, packaging or machining—Alcoa has the right man on the spot in 24 hours. And that man has the right answers. Alcoa's technical services are, in effect, an actual part of our developmental facilities. The jobs we've worked out together meet the high standards of Underwriters' Laboratories and Canadian Standards Association. At every level, Alcoa has made sure we are satisfactorily served."

IN ENGINEERING

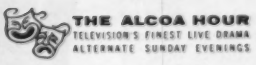
George Smith, Chief Engineer, says, "We think Alcoa's engineering data and technical assistance set the standard and give us firm foundations of fact on which we can make decisions. I recall one specific case of many . . . Alcoa lubrication engineers gave us information that enabled us to increase tool life dramatically. Typical of the aluminum screw machine parts we make are components for toggle switches, including bat handles, bushings and mounting nuts. Close tolerances are a must. A variation of as little as .001 inch in some switch parts means the device just won't work. Yet, with aluminum, the parts fit together nicely, work smoothly."

IN PRODUCTION

Edward Palczewski, Foreman of the Screw Machine Department (shown with operator), says, "We've been cutting aluminum during the ten years I've been with Leviton. We have one job running on a high-speed Davenport which does 120 pieces a minute. It consists of forming, drilling, tapping and threading 19/32-inch rod. We're running the machine at top capacity. Swaging diminishes the machinability of some metals—takes away their free-cutting qualities. Aluminum's properties are retained no matter what we do with it—doesn't get stringy or lose machinability. During setup, tools can be set dry. The operator can see what he's doing—saves a lot of time. Cutting oils are lighter, cheaper. Stock is easier to handle."

IN PURCHASING

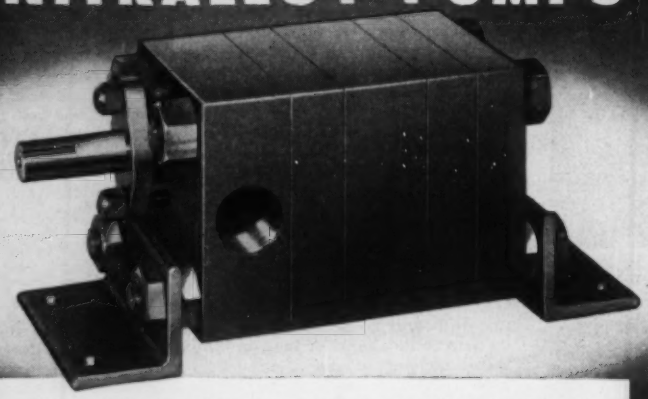
Joseph Wolfson, Purchasing Agent, says, "Our Purchasing Department at Leviton demands dependability from suppliers. It is this simple fact that has characterized our relationship with Alcoa for over 15 years. Use of Alcoa Aluminum Screw Machine Stock has helped us to reduce our inventory and order problems; for example, one Alcoa alloy offers advantages of free cutting and free swaging. Once, when we increased production on a certain job and ran into low-stock problems, Alcoa's early delivery service really helped us out."



Your Guide to the Best in Aluminum Value

Circle 500 on page 19

NORTHERN
NITRALLOY PUMPS



Unique block construction permits selection from a wide choice of metals for virtually any pumping need. Proven in thousands of installations . . . backed by 50 years of engineering and production experience. Unexcelled for precision manufacture, accurate assembly and dependable, long-life operation. Pressures to 2,000 PSI. Capacities from ¼ to 146 GPM. *Write for free catalog and engineering data.*

NORTHERN ORDNANCE, INCORPORATED
Subsidiary
NORTHERN PUMP COMPANY
MINNEAPOLIS 21, MINN.

Circle 501 on page 19

Why leading manufacturers are "SWITCHING" WITH DENISON

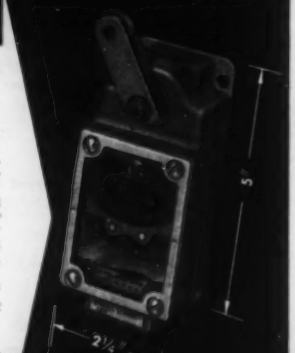
LOXSWITCH

HEAVY DUTY LIMIT SWITCHES

Operates Over 1 Year Under A Constant Flush of Coolant!

On a group of machines in an automotive plant Loxswitch limit switches are still operating after a year under a constant flush of coolant (previous switches failed in less than a week). When manufacturers hear of a machine tool limit switch that gives results like this—at no increase in price—it's only natural that they change to Loxswitch. Obtain these same amazing results. Write or phone for a copy of Catalog 956.

LOXSWITCH Is a registered trade mark for limit switches—pronounced lock-switch.



Specializing Exclusively in the Manufacture of Limit Switches.

R. B. DENISON MFG. COMPANY
102 ST. CLAIR AVE. N.W. • CLEVELAND 13, OHIO

Circle 502 on page 19

New Parts

(*Continued from Page* 163)

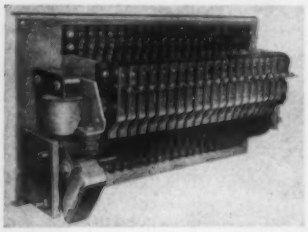
vibration-resistant connection between fittings and hanger. Stainless-steel thread insert has strength of 200,000 psi. **Western Sky Industries,** Hayward, Calif.

Circle 683 on page 19

Step Switch

cam-operated unit has 1 to 20 independent circuits

Heavy duty MT Series step switch has contact rating of 10 amp. Rotary-solenoid actuator operates on 115 v 60-cycle ac without rectifiers. Independent cam-operated



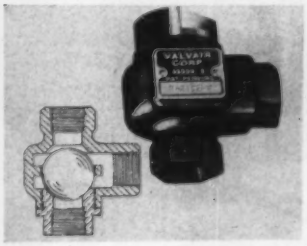
contacts may be set for any combination desired for 1 to 20 circuits. Switch simplifies circuits and eliminates auxiliary relays and other components. Unit provides interlock between sequence operations on machines and similar applications. **Eagle Signal Corp.,** 200 20th Street, Moline, Ill.

Circle 684 on page 19

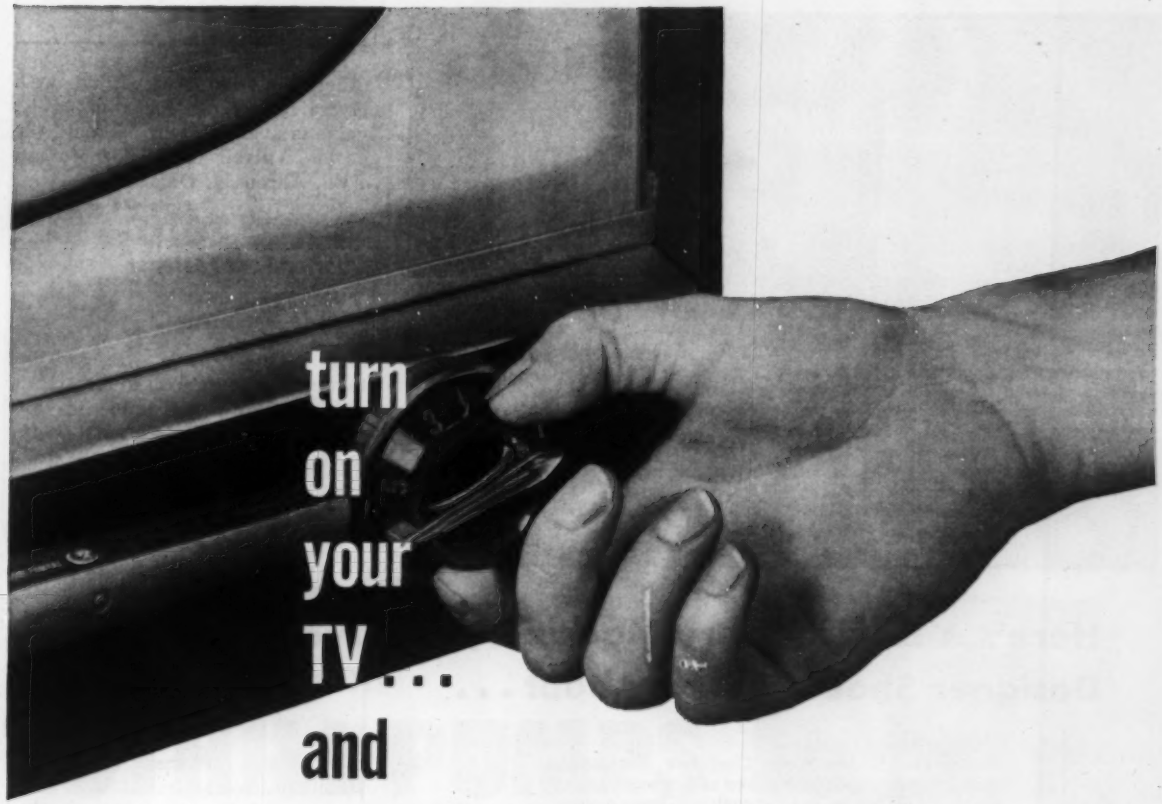
Directional Valve

allows switching from automatic to manual control

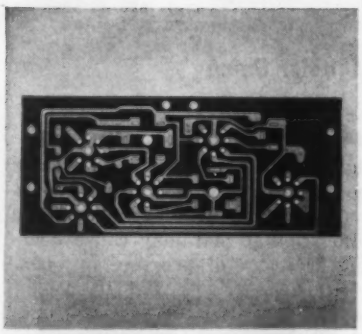
Directional valve, installed as tee in cylinder or valve inlet lines, affords instant switch-over from automatic to manual control, or



control from two different sources. It can also be used to prevent intermixing of supply when two gases or liquids are delivered alternately. Suitable for air, oil, water or



Synthane laminated plastics report for work



Printed circuit for popular television receiver uses a metal-clad Synthane Laminate. Such a circuit eliminates wiring, wiring errors, saves space and weight.

Since the time when the heart of radio was the crystal and cat's whisker, Synthane laminated plastics have been the recommended insulation in the vital and ever expanding communications industry.

Turn on your TV or radio and Synthane goes to work as insulation in coil forms, transformers, tuners, plug-ins, switches, potentiometers, or as the metal-clad base for the entire printed circuit. Synthane also qualifies for important work in radar, sonar and guided missile applications.

Among the varieties of Synthane laminated plastics are several with insulation resistance and dissipation factor capable of controlling TV's high frequencies —even under tropically humid conditions. But Synthane makes over 30 grades—each with its own proportion of useful mechanical, electrical and chemical virtues. You can buy Synthane laminated plastics in sheet, rod and tube form or avail yourself of our complete fabrication service.

We have a number of interesting and informative folders on Synthane properties and applications. A post card will bring them to you promptly. Synthane Corporation, 5 River Road, Oaks, Pa.

COMPRESSIVE STRENGTH

DIELECTRIC STRENGTH

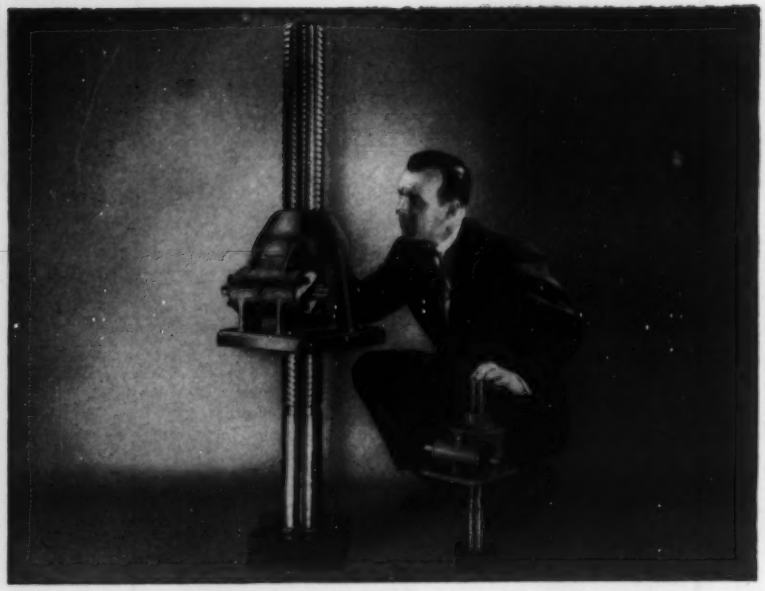
LIGHT WEIGHT

WEAR RESISTANCE

SYNTHANE ...industry's unseen essential

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

Circle 503 on page 19

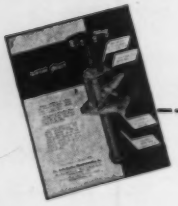


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 6¼:1 to 27:1; turn of worm for each 1-inch raise, 10 to 40; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.



DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

New Parts

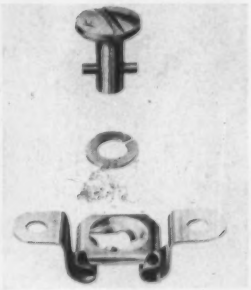
other materials compatible with Hycar ball check and bronze body, valve is available with ¼ and ⅜-in. ports. **Valvair Corp.**, 454 Morgan Ave., Akron 11, Ohio.

Circle 685 on page 19

Quarter-Turn Fastener

small unit joins sheet metal panels

Small, inexpensive, lightweight fastener having high strength-weight ratio is adaptable to thin materials and miniaturized equip-



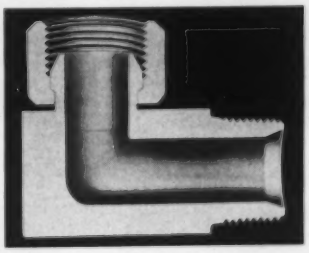
ment like airborne electronics, small electromechanical and computing devices and communication equipment. Designated Camloc 5F, fastener is available in many head styles. Stud shank is 13/64-in. diam. **Camloc Fastener Corp.**, Spring Valley Rd., Paramus, N. J.

Circle 686 on page 19

Adapter Union

turbulence free fitting has smooth bore

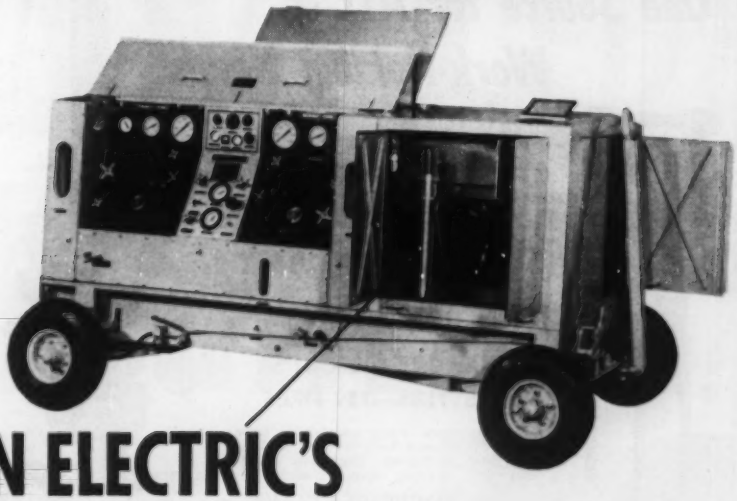
Adapter union has completely rounded bore with smooth radius at all angles to eliminate turbulence and friction that may cause heating and loss of pressure or effic-



iency. Male ends of unions are tapered to eliminate presence of any shoulder at juncture with adjacent fitting. Union is available in various materials and pipe sizes

ANOTHER PUMP PROBLEM...SOLVED BY **TUTHILL**

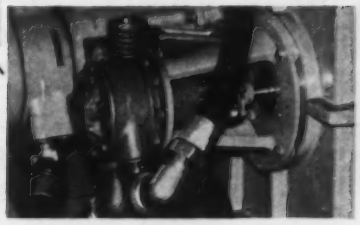
Operates from -65° to 130° F



SUN ELECTRIC'S

Aircraft Hydraulic Systems Tester with

TUTHILL PUMPS



The Model AHT-30-A Sun Aircraft Hydraulic Systems Tester, shown here, has a tough assignment. Designed to simultaneously test in the field the hydraulic systems on two jet aircraft, without operating the aircraft engines, the tester must function under rugged operating conditions. For example, it must operate at temperatures from —65°F to 130°F...at altitudes from sea level to 6000 feet...at relative humidities from 95 to 100%.

These unusual operating conditions obviously dictate the choice of a special and unusual hydraulic fluid. The fluid finally selected met all requirements but had one drawback—it was tough on hydraulic pumps.

Like many others, Sun's engineers found the answer to their pump problem at Tuthill. A special modification of Tuthill's Model 4CB pump provided the backbone for the two separate hydraulic systems in Sun's Tester. The Tuthill pump is used to supply booster service by supercharging on the suction side of a standard high-pressure hydraulic pump. This combination allows the Sun Tester to deliver hydraulic fluid at the rate of 20 gpm at a pressure of 3000 psi through either or both of its two independent hydraulic systems.

Model CB, used in the Sun Tester, is a compact, dependable, self-priming, positive displacement pump with a special Tuthill mechanical shaft seal and built-in ball bearings, designed for directional operation. With an economical first cost, it requires negligible maintenance resulting in extremely low operating costs.

Model CB may provide the answer to your pump problem—or one of the other 750 models in the Tuthill line may supply your needs. If your requirements can not be met by one of our standard models, Tuthill engineers will work with you in developing a modification for your particular application.

If you have a pump problem, your Tuthill representative probably has the answer. Why not call him today?

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
Gentlemen:
☐ Please send me information on the Model C Series
☐ Please send information on the complete Tuthill line.

NAME_____ TITLE_____

COMPANY_____

STREET_____

CITY_____ STATE_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

Circle 505 on page 19

One Source for ALL Work-Holding Needs

• • •

TOGGLE CLAMPS

39 TYPES and SIZES

Featuring REAMED HOLES, for better bearing — HARDENED BUSHINGS—SERRATED to prevent turning — HIGH TENSILE STRENGTH RIVETS for longer service.

WESPO

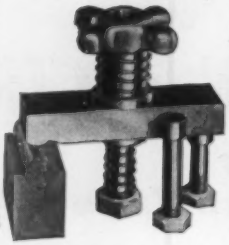
NEW — TOGGLE PLIERS

Movement of Trigger in either direction, releases pressure on Plier.

FIXTURE CLAMPS

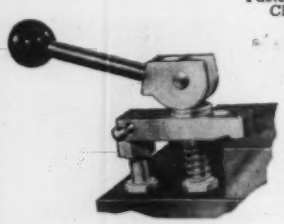
16 STYLES—159 SIZES

WESPO fixture clamp assemblies save up to 70 percent on your own designing and machining. They are standard with leading manufacturers.



NEW — SWINGLOCK CLAMP

Fastest Hand Operated Clamp Available.



COMPONENTS

1000 TYPES AND SIZES

Write for Catalogs

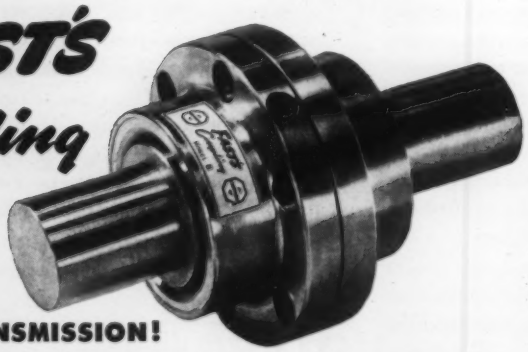
WEST POINT MFG. CO.

26941 W. 7 Mile Road • Detroit 19, Michigan

Circle 506 on page 19

The incomparable Model B

FAST'S Coupling



LOW-COST POWER TRANSMISSION!

Designed for light and medium drives—fans, blowers, pumps—a lighter, smaller and lower priced Fast's Coupling! The same famous features found in all Fast's Couplings . . . the same mechanical flexibility, the same positive lubricating principle, the same rugged construction and trouble-free performance . . . the same highly efficient power transmission which has made Fast's Couplings the leader for more than 30 years! Available for shaft sizes up to 2⅞" and sold with Koppers' free engineering service. For the low-cost solution to your shaft coupling problem, write: Koppers Company, Inc., *Fast's Coupling Dept.*, 3502 Scott Street, Baltimore 3, Md.

THE ORIGINAL

KOPPERS

FAST'S Couplings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus. Engineered Products Sold with Service.

Circle 507 on page 19

New Parts

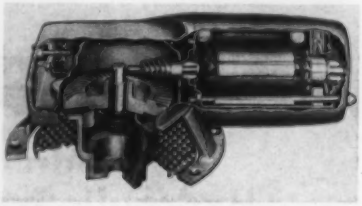
in 45 and 90-deg styles. **Eastman Mfg. Co.**, Twelfth Street, Manitowoc, Wis.

Circle 687 on page 19

Electric Starter

for small gasoline 2 and 4-cycle engines

Pushbutton operated electric starter for small gasoline engines operates on either 12-v battery or 110-v ac power. Battery-operated



unit is provided with charger which operates on 110 v ac. Rating is 10 amp-hr, giving 150 or more starts per charge. Compact, efficient unit uses Spiroid direct-gear drive to assure minimum maintenance. **Fairbanks, Morse & Co.**, Magneto Div., Beloit, Wis.

Circle 688 on page 19

Servo-Parts Kit

enables assembly of mechanical servo components

Miniature-servo mechanical parts are for 400-cycle servo systems for applications where space is at a premium and low system inertias are required. All essential mechan-

ical parts necessary for assembly of servo system are available, including miniature slotted mounting plates, hangers, dial assemblies, mechanical and electrical stop assemblies, couplings, differentials, and gears in various pitches. Parts are for use with ⅛-in. shafting. Hangers are mounted to slotted plate by T-nuts, permitting continuous adjustments in both directions for proper meshing. Parts

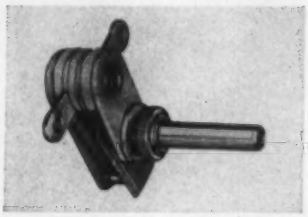
are available in kit form or separately. **Reeves Instrument Corp.**, 207 E. 91st St., New York 28, N. Y.

Circle 689 on page 19

Panel Thermostat

is preset device for fan control

Bimetal thermostat, model A-7P, has threaded bushing for one-hole mounting on control panel of fan. Unit is sensitive to slight changes in room temperature and can be



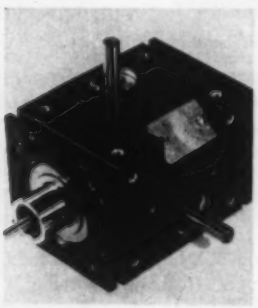
precalibrated, as in 30 to 120-F range. When temperature falls below preset temperature, thermostat contacts open. Unit is available with screw terminals or terminals for push-on connectors. **American Thermostat Corp.**, South Cairo, N. Y.

Circle 690 on page 19

Sphere Resolver

is miniature unit for analog computators

Miniaturized, precision mechanical-ball resolver for analog computation applications has 0.1248-in. in-



put shaft which may be driven up to 100 rpm. Less than 5 oz-in. is required at 25 C for an output of 1 to 2 oz-in. at the 0.187-in. sine and cosine output shafts. Orientation shaft, 0.500-in. diam, is concen-

(*Continued on Page* 174)

ADVANCED!

...SINTERED POWDERED METAL BEARINGS and PARTS

by **Bunting!**®

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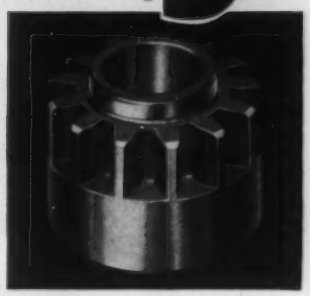

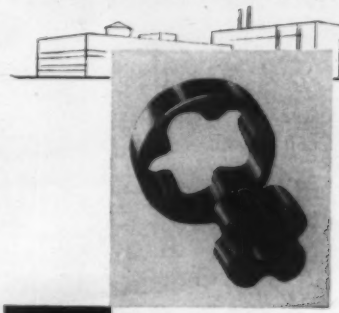

Bunting resources, reputation and responsibility together with a complete new plant and modern equipment provide Sintered Powdered Metal products at a high point of quality and precision.

Bunting Engineering is available without cost or obligation to all. Write for new Bunting Engineering Hand Book. 24 pages packed with new technical data on powdered metal products manufacture and application.

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BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 508 on page 19

Ross Exchangers cool this Superior Diesel Generating Set

Giant gate cranes and hoists are hard at work on the Long Sault Dam at Massena, N. Y., a part of the tremendous St. Lawrence Power Project. Supplying the power for these machines during construction, and scheduled for standby service after completion is this Superior 500 KW Model 40 Diesel Generator Set.

To maintain correct operating temperatures at all times, two Ross Exchangers have been furnished. One cools the lube oil. The other cools the jacket water. *Overheating is prevented and dependable performance thus assured.*

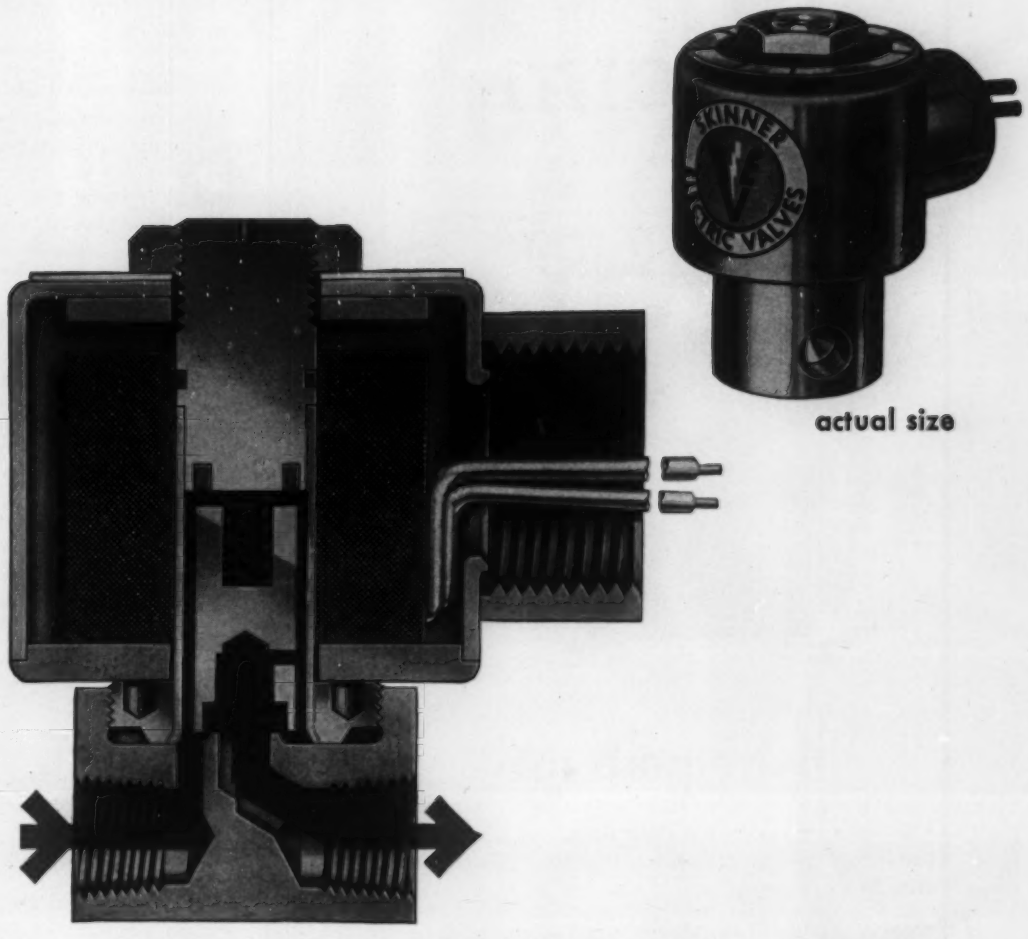
Testifying to the ruggedness and thermal efficiency of Ross Exchangers, the White Diesel Engine Division reports: "Ross Exchangers are used on our Superior Model 40 Engine . . . We are marketing a high quality product, and expect any component which we furnish to be of the same high quality."

You'll find Ross Exchangers serving practically all makes of engines, compressors and turbines. Pre-engineered and fully standardized, they're available in a wide variety of designs and sizes to answer your needs.

For more information, request Bulletins 1.1K5 and 2.2K1. Ross Heat Exchanger Division of American-Standard, Buffalo 5, N. Y. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS HEAT EXCHANGER

Division of AMERICAN-Standard



actual size

New C-series solenoid valve offers recognized "Skinner Quality" at low cost

This is a faithful reproduction—in miniature—of the time-tested, 2-way, normally closed Skinner V5 except that the body is made of brass.

This new, compact Skinner valve weighs only 12 ounces, yet it's rugged enough to last millions of cycles on most applications.

This new valve has orifices from 5/32" to 7/64", with pressures ranging from 60 to 130 psi. Pipe size is 1/8" NPT. It is a packless, direct-acting valve with only two moving parts. And it's absolutely bubbletight—even on vacuum. This C-Series Skinner valve is fail-proof, too—a built-in spring return assures positive closing; thus it can be mounted in any position and is ideal for direct-line mounting.

You'll find this new valve, with its recognized "Skinner Quality," the perfect low-cost answer to a wide range of flow control problems. It works efficiently with air, water, oils, gasoline and many other media. Typical applications include: automotive fuel systems, welding equipment, vending machines, lubricating devices, spraying equipment, air horns, water softeners, humidifiers and instrumentation.

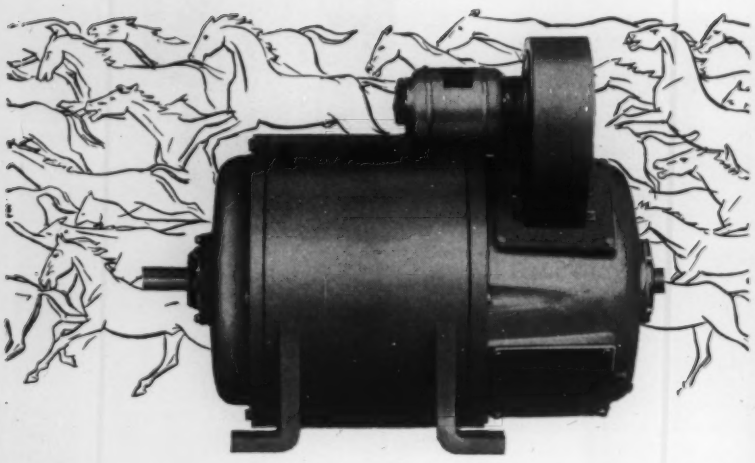
Our Bulletin D11.1 contains complete information on this valve—flow curves, optional features, dimensions, electrical data, etc. We will be happy to send you a copy on request.

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
THE SKINNER CHUCK COMPANY

Circle 510 on page 19

SPECIAL



five equals fifty

This DC motor is actually ten times the motor it appears to be. It is the size of a 5-h.p. motor, but it's rated 50 h.p. short-duty, and over 20 h.p. continuous.

In designing this particular shunt-wound motor, high power in a small space was the major consideration, but not the only one. It also had to accelerate to 6000 r.p.m. within one second and withstand frequent, fast reversals without excessive overheating. Physically, this small-scale giant measures just 16" long by 9½" dia., and weighs only 115 lbs.

Admittedly, this is a special motor. It is also typical of ESCO's unusual ability to design and build all kinds of special rotary equipment to meet particular needs. For over forty years ESCO has been pleasing its customers by finding answers that exactly match special requirements. Perhaps our solution to your particular motor problem will please you, too.

Refer to Esco Catalog in section 4a/E1 in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem — we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

New Parts

(*Continued from Page* 171)

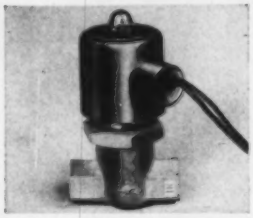
tric with the input shaft and establishes output relation with accuracy of ± 0.5 per cent over 360 deg range. **Vectron Inc.**, 1604 Trapelo Rd., Waltham 54, Mass.

Circle 691 on page 19

Miniature Valve

solenoid unit handles air pressures to 100 psi

Solenoid valve for pneumatic pressures to 100 psi has ⅜ or ¾-in. orifice. Continuous-duty solenoid



is available in ratings from 6 v dc to 440 v ac. Overall length of ⅜-in. valve is 2 17/32 in; ¾-in. valve is 3¾ in. long. Coil is 2 in. diam. **Hays Mfg. Co.**, Dept 308A, W. 12th St., Erie, Pa.

Circle 692 on page 19

Filter Medium

may be fabricated without altering mesh size

Rigidized wire mesh has plate-like characteristics that permit fabrication by cutting, rolling, corrugating or welding without loss of original uniformity of mesh openings. Filter element can be given accurate, un-

alterable particle-size retention rating. Material can also be used as two or more layers homogeneously bonded together, forming a laminate. Assembly combines very fine filtration qualities with high mechanical strength. Particle-size retention rating is 2 to 2000 microns. **Pall Filtration Co.**, 30 Sea Cliff Ave., Glen Cove, N. Y.

Circle 693 on page 19

2 OPERATIONS 1 MOTION

Tap and Fasten Simultaneously with

EATON-RELIANCE

Thread-Cutting Springtites and Sems

Time expended and cost are both high in any production operation where metal must be tapped for bolt or screw type assembly. By eliminating the tapping operation, both of these factors can be reduced and resulting savings will be reflected immediately in the end cost of the product.

Eaton-Reliance Thread-Cutting Springtites and Sems have been designed specifically to give production men the advantage of accomplishing two operations with one motion. These fasteners tap and fasten at the same time.

In addition to the time and cost saving advantages, Thread-Cutting Springtites and Sems assure a tightly fastened assembly. As threads are cut, the screws are seated firmly without allowing a chance for mismating or stripping. An added plus is the preassembled Spring Washer, properly engineered to maintain constant tension. Put these fasteners to work in your assembly operation NOW.

Write for a visit from one of our fastening engineers or send for your free copy of Engineering Bulletin S-49A today.

EATON — *RELIANCE DIVISION*

MANUFACTURING COMPANY

506 CHARLES AVENUE • MASSILLON, OHIO

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PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

NOW-A Better Rotary Joint!

Patent Pending

SIZES
½" ¾" 1" 1¼"
1½" 2" 2½" 3"

NEW BARCO TYPE C Rotary Joint

Announcing...

It's new! It's simple! It's versatile! And for countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had.

FOR ALL SERVICES—One basic style of revolving joint for single flow or syphon flow ... one basic seal for steam, air, water, oil, gas — *or alternating hot and cold!* For temperatures to 450°F. Special to 500°F.

NO LUBRICATION NEEDED — Bearings and seal self-lubricating. Seal self-adjusting for wear. Long life without repairs or maintenance.

LOW TORQUE — Low starting and running torque*. Saves power. Suitable for any ordinary speed. To 200 psi, steam, or 400 psi, hydraulic.

COMPACT, SIMPLE — Malleable iron body; heat treated steel shaft; R.H. or L.H. thread. Eight sizes, ½" to 3".

*Typical example: 12 in. lbs. starting torque for 1" Type C on 100 psi water. Rotating torque, same.

for

STEAM
WATER
OIL
AIR or GAS

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506C Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

Circle 513 on page 19

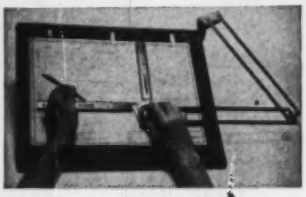
ENGINEERING DEPARTMENT

EQUIPMENT

Drafting Machines

in portable units for right and left-hand use

Two sizes of portable drafting machines are available in right and left hand models. Machines are mounted on tempered Masonite



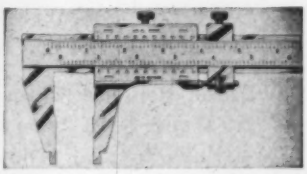
and take drawing sheets 12 x 18 in. or 15 x 20 in. Detachable blades are stainless steel. **Drafting Equipment Co.**, 504 Randolph St., Meadville, Pa.

Circle 694 on page 19

Vernier Caliper

in 12 and 24-in. lengths is easily read to 0.001-in.

Vernier caliper, with 50 divisions on vernier scale, may be read or set to 0.001-in. without magnifying



glass. Vernier plates are flush with main scale, eliminating errors due to parallax. Reading surfaces are satin-chrome, rest of instrument is hard-chrome plated. **L. S. Starrett Co.**, Athol, Mass.

Circle 695 on page 19

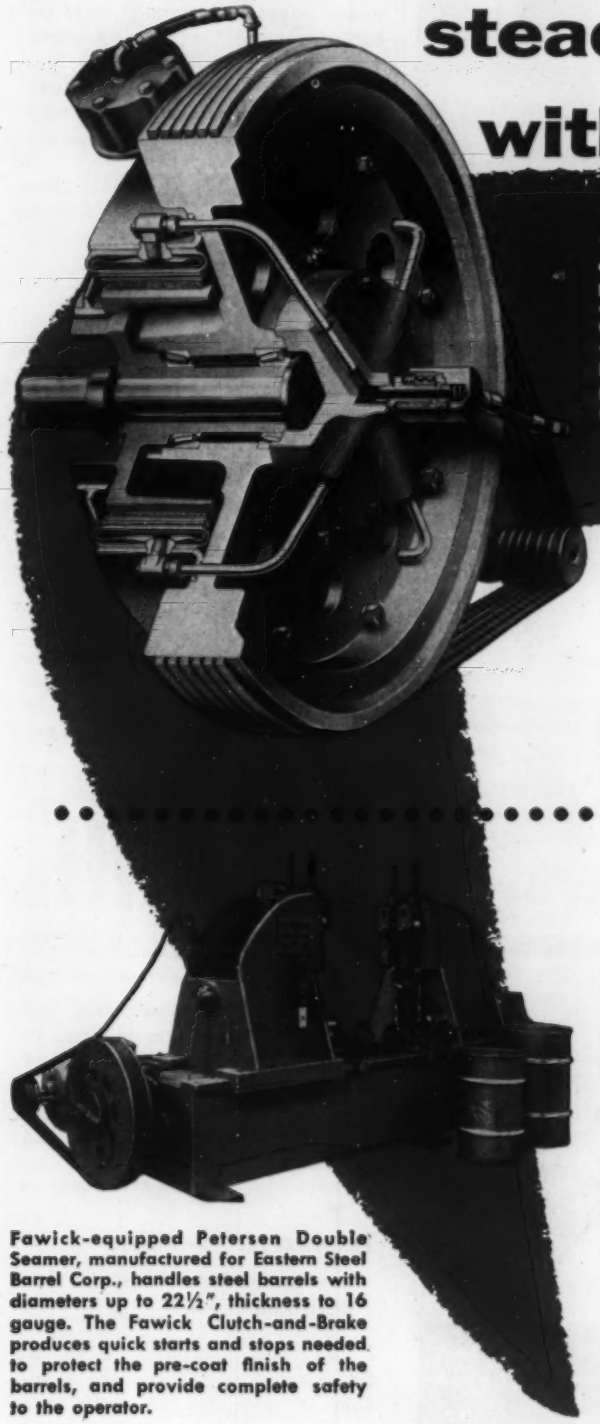
Photometer

has high accuracy and sensitivity

Model PH-200 photometer utilizes maximum performance of commercially available photomulti-

FSPA* takes tough, steady punishment with no downtime

*Fawick Standardized Press Applications are complete packages for conversion of production machinery to modern pneumatic control. They consist of a Fawick CB Airflex Clutch, CS Brake, Rotorseal and new flywheel mounted on anti-friction bearings. FSPA increases machine production, improves safety, lengthens life and cuts maintenance.



Fawick-equipped Petersen Double Seamer, manufactured for Eastern Steel Barrel Corp., handles steel barrels with diameters up to 22½", thickness to 16 gauge. The Fawick Clutch-and-Brake produces quick starts and stops needed to protect the pre-coat finish of the barrels, and provide complete safety to the operator.

A FAWICK Standardized Press Application has been selected by Petersen Tool & Die Works, Inc., for use on its new Double Seamer which is capable of producing a new barrel every five seconds! Reason: they needed a clutch and brake that could continuously produce split-second starts and stops, and fast steady cycling—without failing. Ordinary mechanical clutches in this service were breaking down as often as five or six times a year. FAWICK Clutches now do this same job without interruption—proof of their ability to stand up under rugged conditions.

Find out how FSPA can improve the operation of your production machinery. For more information, contact your nearest FAWICK Representative, or write the Home Office. Ask for Bulletin ML-172.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada Ltd., Toronto

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

Circle 514 on page 19

MECHANICAL ENGINEERS

Military electronics projects of increasing magnitude and complexity have created exceptional career potentials for mechanical and electromechanical engineers at Hoffman. If you are keenly interested in enhancing your professional stature, and prefer to work for a growth leader in the electronic field, you are invited to write Vice President of Engineering:

Hoffman LABORATORIES, INC.
A SUBSIDIARY OF HOFFMAN ELECTRONICS CORP.
3761 South Hill St., Los Angeles 7, Calif.
Telephone: RIchmond 9-4831.

Circle 515 on page 19

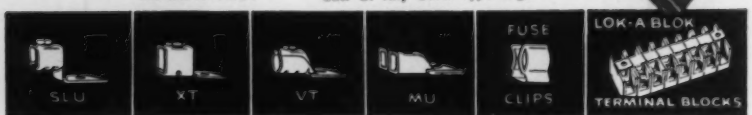
ILSCO THE BIG LUG OF INDUSTRY

For Superior Quality
√ Check these features

- ☐ Pure copper, 100% conductivity
- ☐ Wide wire range—re-usable
- ☐ U/L-CSA Approved
- ☐ Compact—rugged
- ☐ Advanced designing
- ☐ Sound engineering
- ☐ Speedy installation
- ☐ Cool operation—takes overload
- ☐ No special tools needed
- ☐ All screws wax-treated for better clamping

ALL THESE FEATURES AT LOW COST

Your √ Test Will Prove ILSCO Superiority Over Cast Or Any Other Type Lugs



Write for Catalog #50 and Samples

ILSCO CORPORATION

5752 MARIEMONT AVE. CINCINNATI 27, OHIO

Circle 516 on page 19

Engineering Equipment

plier or photoelectric tubes. Having a highly regulated electronic power supply, instrument uses no batteries and is self-contained and portable. Flexibility is enhanced by separate zero and dark-current adjustments as well as both decade and continuously

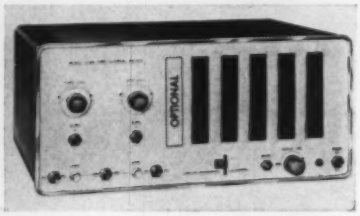
variable sensitivity controls. **El Dorado Electronics Co.**, 1401 Middle Harbor Rd., Oakland 20, Calif.

Circle 696 on page 19

Time Interval Meter

measures from 10 mu sec to 1 sec

Unit provides precise measurement of elapsed time between two events occurring within range of 10 microseconds to 1 second. Ac-



curacy is ± 10 microseconds. Optional range extension is from 10 to 100,000 seconds. Sensitivity of 0.07 v rms is provided between −50 and 50 v. **Computer-Measurements Corp.**, 5528 Vineland Ave., North Hollywood, Calif.

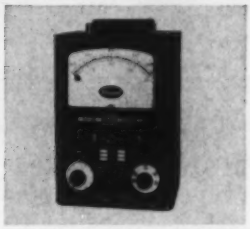
Circle 697 on page 19

Temperature Controllers

are thermistor-actuated dual range units

Dual-range thermistor-actuated temperature controllers are available in two models with two ranges each: Model 56006 has 100 to 300 and 200 to 600 F ranges; Model 56007 has −100 to 50 and 0 to 150 F range. Selector switch on panel determines range being

Engineering Equipment



used. Units have either on-off control or time-modulated proportioning. **Fenwal Inc.**, 113 Pleasant St., Ashland, Mass.

Circle 698 on page 19

Ratio Meter

checks synchros and synchro systems

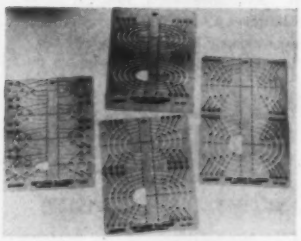
Model 100 transformation - ratio meter reads voltages of synchros to ± 0.2 per cent. Indication is di-

rect percentage deviation of transformation ratio of synchro from ideal ratio. **Beckman Instruments Inc.**, Shasta Div., Box 296, Station A, Richmond, Calif.

Circle 699 on page 19

Ellipse Templates

for ellipses with 2 to 6 in. major diam

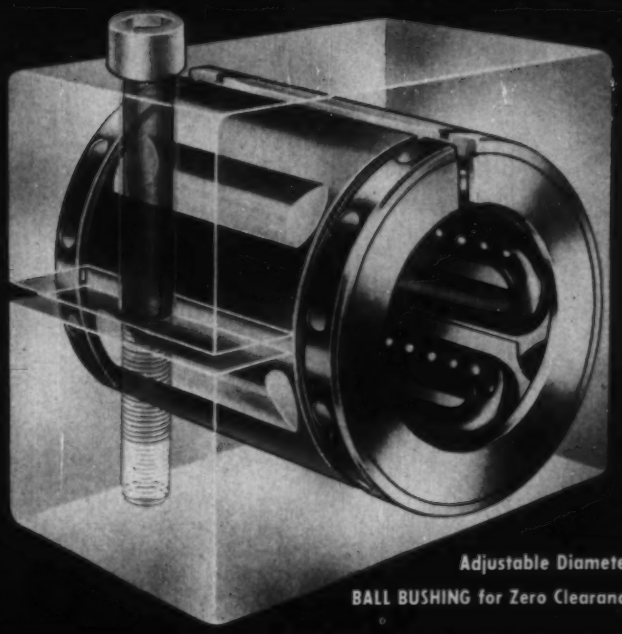


Large-ellipse template set consists of four units with 20, 30, 45 and 60-deg projections. Each has a range of 2 to 6 in. major diam in

NOW! *Adjustable Diameter and Open*

THOMSON

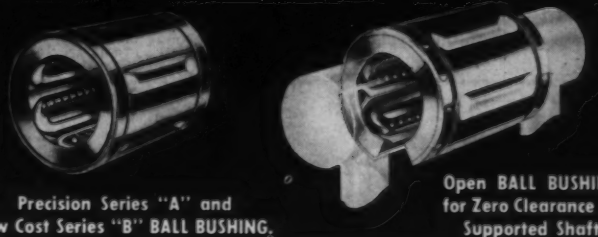
BALL BUSHINGS



Adjustable Diameter BALL BUSHING for Zero Clearance

The BALL Bearing for *all your*

LINEAR MOTIONS



Precision Series "A" and Low Cost Series "B" BALL BUSHING

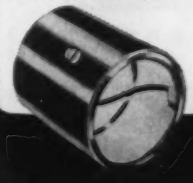
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



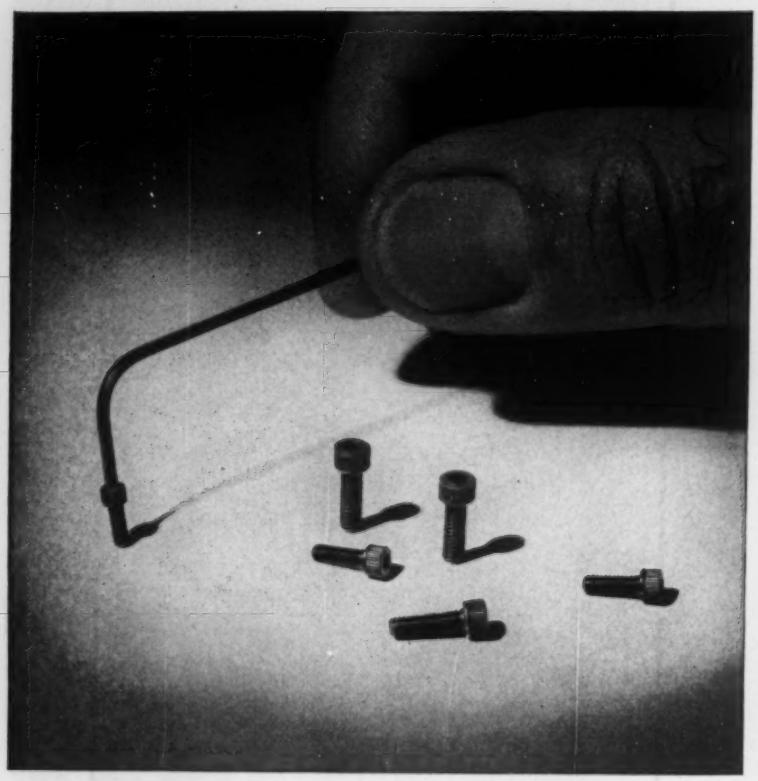
THOMSON INDUSTRIES, Inc.

Dept. E, MANHASSET, NEW YORK

Also manufacturers of NYLINED Bearings ... Sleeve Bearings of DuPont NYLON

Circle 517 on page 19

Miniature screws aid standardization of small devices



Standard UNBRAKO miniature socket head cap screws are available in sizes # 0, # 1, # 2 and # 3, in heat treated alloy steel or stainless steel, at your authorized industrial distributor's. Standard lengths range from ⅛ to ½ in.

Tiny close-tolerance Unbrako screws available in standard sizes

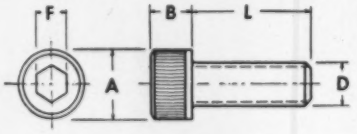
New economies in the design of space-saving miniature equipment are possible with these UNBRAKO miniature socket head cap screws. Manufactured to timepiece precision, available locally, they save the costly necessity of designing special screws to fasten tiny parts in compact units. They're ideal for use in typewriters, calculators and computers, servomechanisms, electric and electronic equipment—and in countless other small, intricate devices where maximum reduction in bulk and weight is required with no sacrifice in strength of individual components or assemblies.

Fingers grip the knurled heads on these tiny screws positively for easy handling and fast assembly. Uniform hex sockets assure maximum wrenching torque. Controlled fillets under the heads prevent shearing of the heads. Threads are fully formed for maximum strength and exact fit. Extremely accurate head diameters permit their use in countersunk holes, saving weight by reducing the length of the screw required and making flush designs possible.

These standard UNBRAKO miniature screws are available at your authorized industrial distributor's. See him today. Or write us for Bulletin 2055 and samples. Unbrako Socket Screw Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

HEAT-TREATED ALLOY STEEL

Class 3 Fit Standard



Diameter		Threads per Inch NC	Threads per Inch NF	Length	Recommended Installation Torque in Inch-Pounds NC	Recommended Installation Torque in Inch-Pounds NF	Weight per 1000 in Pounds
#0	A .104		80	⅛		2.0	.152
	B .060		80	3/16		2.0	.182
	D .060		80	¼		2.0	.210
	F .050		80	⅜		2.0	.265
#1	A .118		72	⅛		3.5	.27
	B .073		72	3/16		3.5	.32
	D .073		72	¼		3.5	.37
	F .050		72	⅜		3.5	.47
#2	A .140	56		3/16	6.0		.42
	B .086	56		¼	6.0		.50
	D .086	56		⅜	6.0		.58
	F 1/16	56		½	6.0		.70
#3	A .161	48		3/16	8.5		.59
	B .099	48		¼	8.5		.70
	D .099	48		⅜	8.5		.81
	F 5/64	48		½	8.5		1.03

Standard Screws are threaded to the head. Special materials, lengths, and threaded lengths are available. One "High-Titan" UNBRAKO hex key is included with each package of 100 screws.

UNBRAKO®

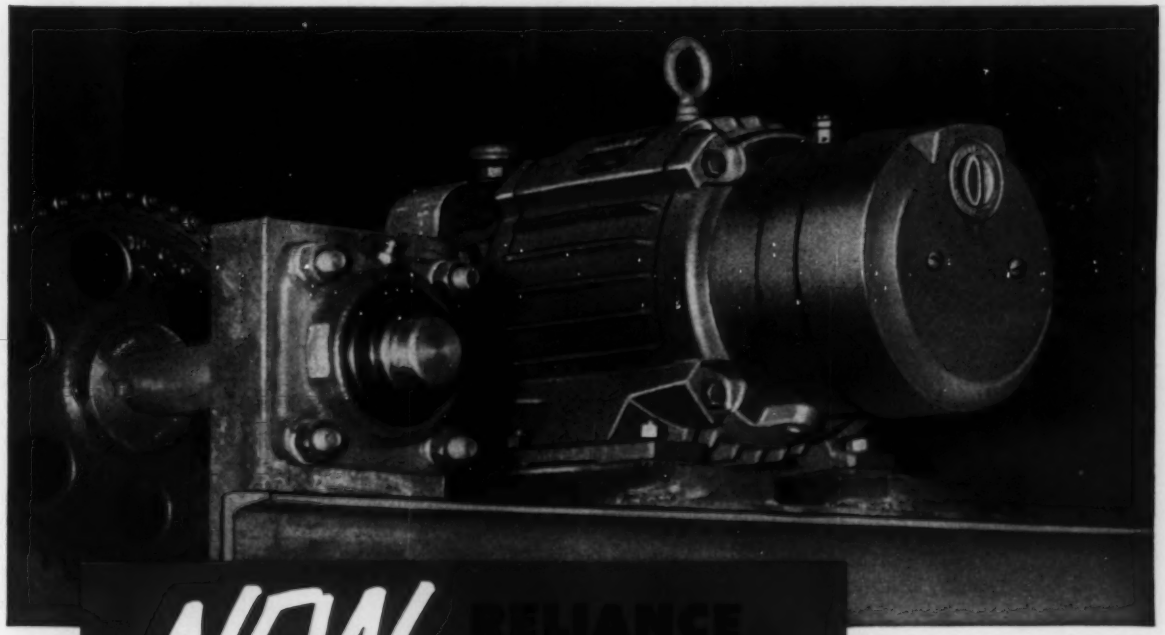
SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

Circle 518 on page 19



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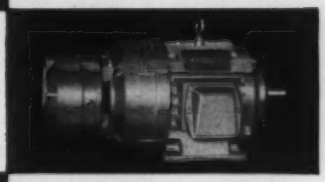
These new motors are specifically designed for tough operating conditions. Corrosion-proof cast-iron housings and sealed joints make this motor impregnable to foreign material.

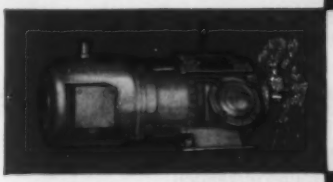
Braking torque ratings from 3 ft. lbs. thru 345 ft. lbs. Fail-safe mechanism immediately applies brake in case of power failure. One piece molded brake linings provide fast, smooth stops and unmatched holding power for heavy loads.

Simple brake has only six parts and requires no control wiring or auxiliary electrical equipment. Compact construction requires a minimum of space. Wearing parts are easily accessible for fast maintenance.

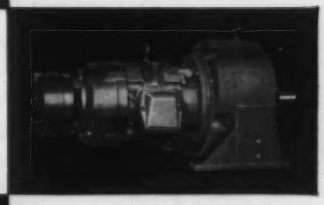
For further information write for bulletin B-2503. B-1533



Totally-Enclosed, Corrosion-Proof



Explosion-Proof—Cl. I, Gr. D and Cl. II, Grs. E, F & G



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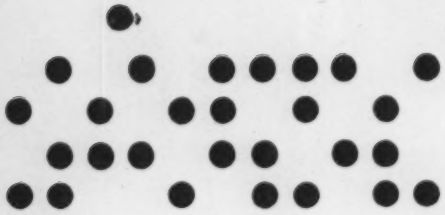

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If you are an experienced computing analyst—or if computing and data reduction are new to you but you are a qualified engineer—there is interesting work as well as a bright future for you in Northrop Aircraft's growing Computer Center at Hawthorne, California.

Applied mathematicians and engineers are needed as computing analysts for assignment to Northrop's analogue computing facility, as well as the newly expanded digital electronic computer department which provides unparalleled service in the practical solution of complex engineering problems.

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If you qualify for any phase of computer research, design or application, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600- F, Hawthorne, California.

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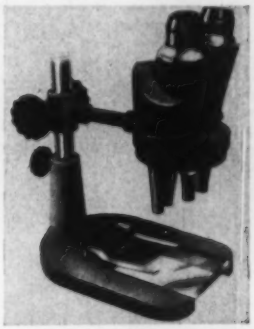
Circle 700 on page 19

Stereo Microscope

provides erect image

Stereo microscope provides up to 3-in. working distance and gives an erect image that is correct as



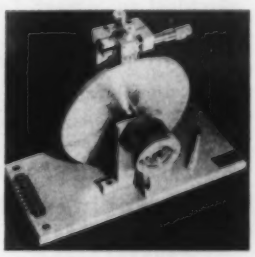
to right and left. Viewer sees wide three-dimensional field with excellent depth perception. Wide-field 8X eyepieces give 21 and 34 power. **Edmund Scientific Co.**, 99 E. Gloucester Pike, Barrington 17, N. J.

Circle 701 on page 19

Rotary Test Head

has excellent repeatability

Rotary test head permits rapid and accurate indexing of shaft position on rotary components such as potentiometers, resolvers and synchros. Fixture has preci-



sion gear fixed to shaft and chuck. Wheel is positioned with rack and micrometer advance, allowing phasing within ½-minute. Repeatability of setting is 1 part in 200,000. **Militest Co.**, 88 Madison Ave., Hempstead, N. Y.

Circle 702 on page 19

S-A 90

SPEED NUTS® WITH A HANDLE

eliminate fastener fumbling!

Multiple-unit strips of Tinnerman Flat-Type SPEED NUTS permit cost-cutting, split-second fastening. That's how Reznor Mfg. Co., Mercer, Pa., saves up to 40% in the assembly of louvers for its Suspended Gas Unit Heaters!

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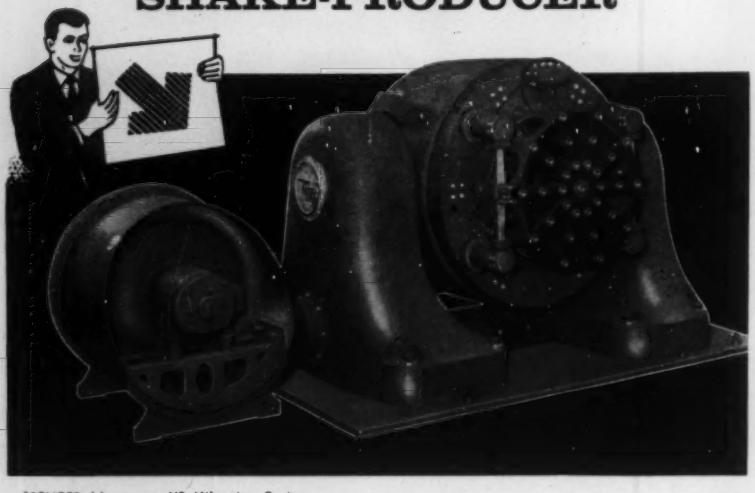
Circle 520 on page 19

a SPENCER BLOWER
cools this powerful
"SHAKE-PRODUCER"



SPENCER blower on MB Vibration Exciter

This vibration machine (more formally designated an "electro-dynamic exciter") exerts a force of 12,500 lbs. . . . is used to test guided missiles, aircraft and other airborne equipment.

In designing the machine, MB engineers faced this problem: heat generated by the electrical fields was tremendous. How could this heat be dissipated most efficiently . . . in a continuous, reliable fashion.

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⅓ HP to 1,000 HP
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THE ENGINEER'S Library

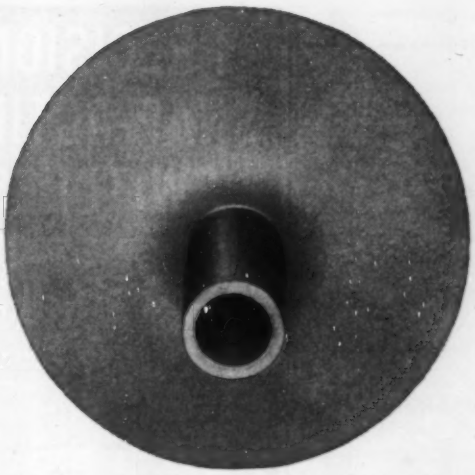
Recent Books

Applied Metallurgy for Engineers. *By Malcolm S. Burton, School of Chemical and Metallurgical Engineering, Cornell University; 407 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 W. 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

This book discusses the metallurgical principles involved in casting, metal working, welding, heat treatment and powder metallurgy. It also discusses these processes from an engineering viewpoint including the metallurgical factors that control selection of suitable processes and the influence of the process on the final products. Emphasis is on the background of metallurgical science essential for proper utilization of metallurgical manufacturing methods. Discussion of techniques and illustrations of industrial equipment is included, but is secondary to the presentation of metallurgical principles. Recently developed processes such as shell molding, inert-gas shielded-arc welding, and vibrationless mid-air forging are considered.

Television Engineering Principles and Practice, Volume II, Video-Frequency Amplification. *By S. W. Amos and D. C. Birkinshaw; 270 pages, 5½ by 8½ in., clothbound; published by Philosophical Library Inc., 15 E. 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, *$15.00 postpaid.*

This volume describes the fundamental principles of video-frequency amplifiers and examines the factors which limit their performance at the extremes of the pass band. A wide variety of circuits is described and particular attention is paid to the use of feedback. There is a section dealing with the special problems of camera-head amplifiers. Because of the nature of the subject, the text is necessarily somewhat mathematical, but self-contained mathe-



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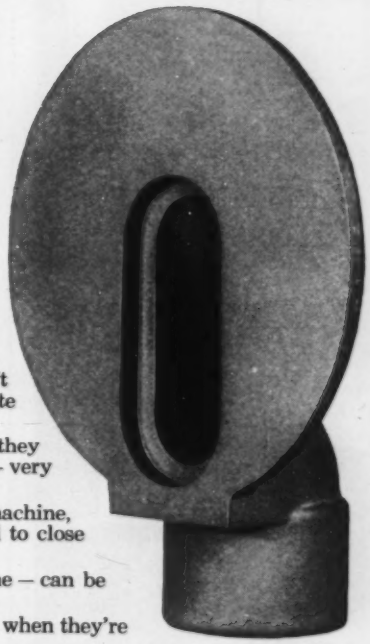

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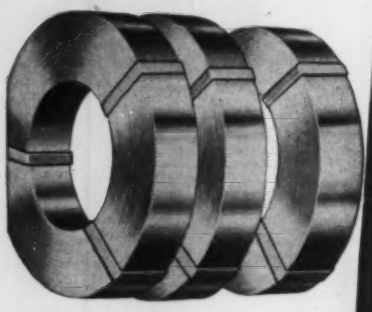

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Library

matical derivations are usually included as appendices at the ends of chapters.

Engineering Analysis. *By Stephen H. Crandall, associate professor of mechanical engineering, Massachusetts Institute of Technology; 417 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 W. 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 postpaid.*

Concerned with the analysis of complex enginering problems and the methods for organizing practical programs for their numerical solution, this book is designed for engineers and engineering mathematicians. The mathematical level is that of second-year engineering graduate work. The arrangement of material is according to a natural classification of the basic types of problems in engineering analysis. Three items frequently omitted in engineering courses are developed: Matrix notation, calculus of variations, and theory of characteristics of partial differential equations. Problems are divided into three classifications: Equilibrium, eigenvalue, and propagation problems. Several physical examples drawn from the fields of elasticity, heat transfer, fluid mechanics, and electrical circuits are given in each chapter to identify the class of problem being treated.

An Encyclopedia of the Iron and Steel Industry. *By A. K. Osborne, technical librarian and information officer, The Brown-Firth Research Laboratories, Sheffield; 558 pages, 6 by 9 in., clothbound; published by Philosophical Library Inc., 15 E. 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, *$25.00 postpaid.*

This encyclopedia provides a concise description of the materials, plant, tools and processes used in the iron and steel industry, and in those industries closely allied to it, from the preparation of the ore down to the finished product, and defines the technical terms employed. The book is intended as a reference, not a textbook. In addition to 475 pages of concise definitions of terms, there is a complete bibliography, and appen-

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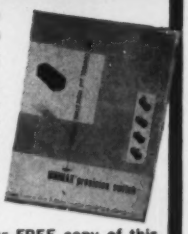

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Division The W. L. Maxson Corporation
IVES ROAD WALLINGFORD, CONNECTICUT

Circle 524 on page 19

dices concerning conversion tables, weights and measures, properties of materials and metals, and mathematical symbols.

Government Publications

Bibliography of the Material Damping Field, PB 121437. *By L. J. Demer, University of Minnesota;* 100 *pages,* 8 *by* 10½ *in., paperbound; prepared by Wright Air Development Center; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $2.75 *per copy.*

This bibliography covers the field of damping of materials and structures. Beginning with a research report in 1784, the volume contains 900 entries extending to 1955. Abstracts are included for all but a few references; arrangement is chronological.

Screw Conveyors, PB 121324. 15 *pages,* 8 *by* 10½ *in., paperbound, sidestapled; prepared by National Research Council, Ottawa; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* 50*c per copy.*

This report is a guide to design of screw conveyors, described as frequently the most suitable conveyor for such bulk materials as ore, coal, clinker, limestone, foundry sand, grain, and food products. The report discusses design and construction of conveyors with particular attention to the screw.

Medium-Speed Digital Plotter, PB 121056. *By P. Kintner and E. White, Aberdeen Proving Ground;* 35 *pages,* 8 *by* 10½ *in., paperbound, sidestapled; prepared by Ballistic Research Laboratories; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.;* $1.00 *per copy.*

This report describes a solution to the problem of digital plotting at medium speeds. The system is built around a stencil-cutting machine and will plot six points per second on a stencil suitable for reproduction by mimeograph or offset processes. The report covers theory of system operation, details of electrical and mechanical modifications to the base machine, and a description of the circuitry.

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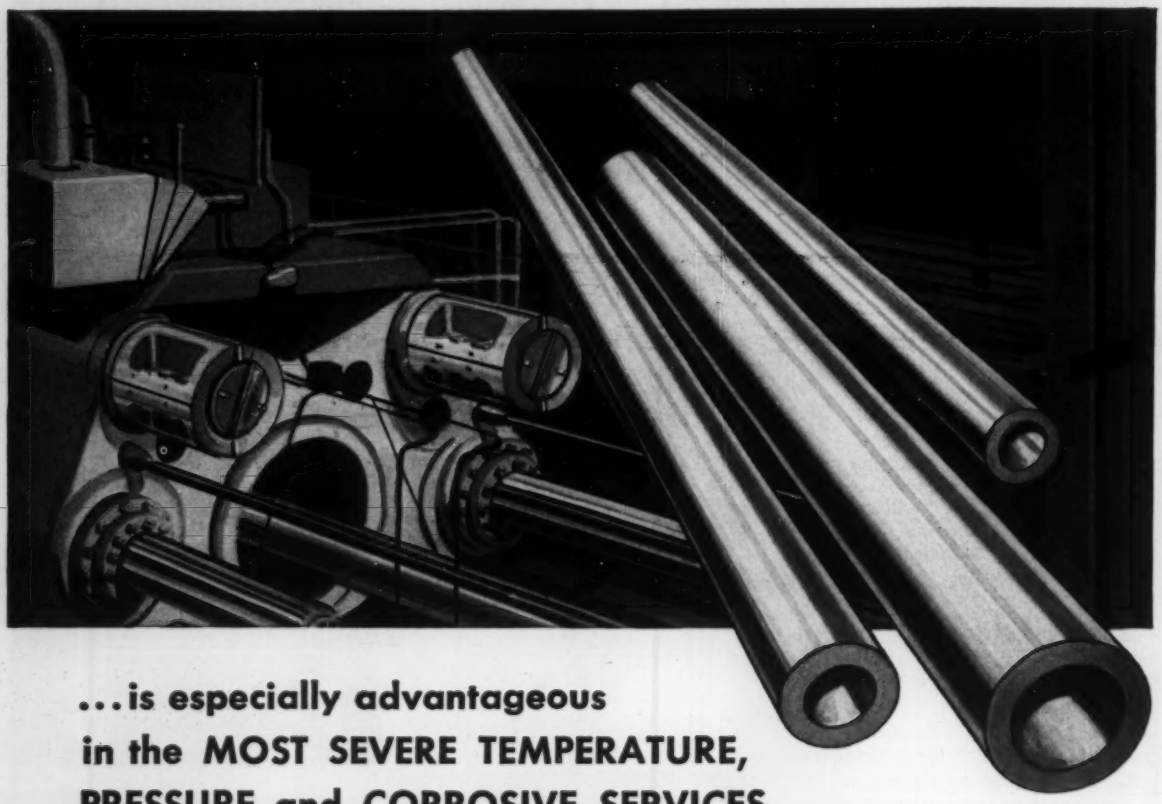

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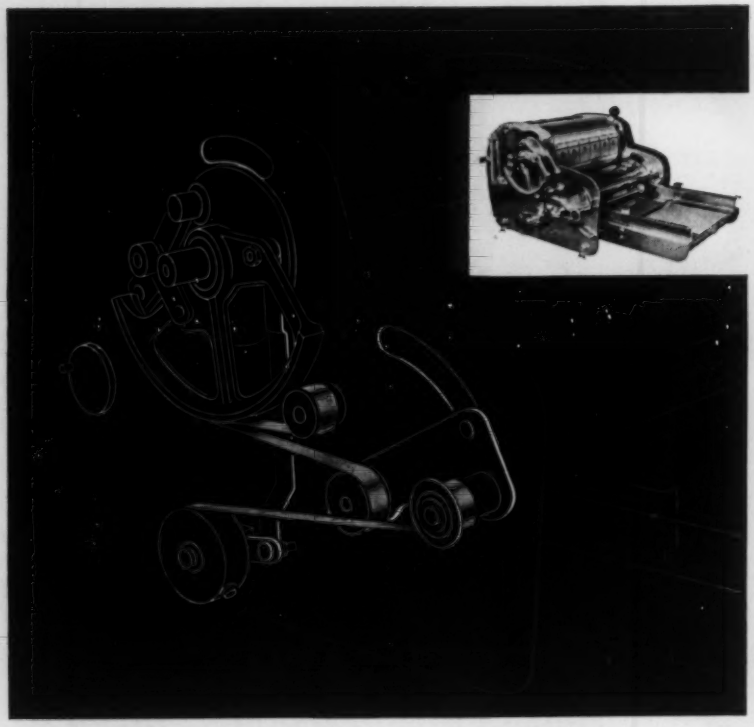

Transmit Motion Without Backlash

USING A NEG'ATOR® SPRING

Quiet, gearless transfer of motion without slippage or backlash—still another function of Hunter's versatile design component, the NEG'ATOR constant-tension Spring.

Searching for a gearless method to link and synchronize the action of paper handling rollers to the timing drive assembly on the new "ROCKET" duplicating machine, design engineers at Standard Duplicating Machines Corp. tried cords, cables, chains—found that NEG'ATOR Springs outperformed all.

So, as illustrated, they attached the free ends of two NEG'ATORS to the cam-and-lever driven timing segment and the free end of a third NEG'ATOR to an idler pulley. The constant tendency of the NEG'ATORS to return to their original coiled condition when extended keeps them taut—eliminates backlash. They rewind smoothly on the drive pulleys as the pulleys are returned, under spring tension, to the cycle starting position.

By replacing gear trains with NEG'ATORS, Standard's engineers obtained efficient operation, longer life, quieter operation, and reduced unit cost. The "ROCKET" is said to be the "quietest machine on the market."

Used in the manner described or to counterbalance without mass, maintain constant pressure, deliver retracting force, power portable units, expand a scale, or perform other functions, the constant-tension NEG'ATOR Spring might offer just what you're looking for.

You can learn more about the NEG'ATOR, its characteristics, forms, functions, and applications by reading Bulletin 310N. Send for a copy.

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New Machines

Materials Handling

Fork Truck: Narrow aisle handling, climbing steep ramps and making long runs are possible in a Warehouser lift truck powered with an engine-generator unit. The engine-generator provides a constant power supply, permitting steady full-shift operation on ramps and with long runs. Power unit fits into a medium-sized battery compartment. It can be used on any Warehouser model. *Yale & Towne Mfg. Co., Yale Materials Handling Div., Philadelphia.*

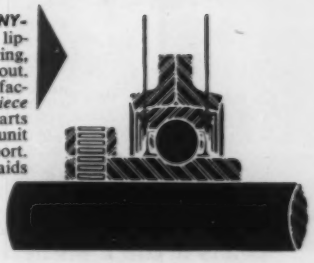
Towing Tractor: Clarktor 80 tractor has 8000-lb maximum starting drawbar pull, low silhouette, and fluid coupling drive. It measures 56½ in. to the top of the steering wheel. With overall length of 107 in. and width of 69 in., it turns in a 146-in. radius. Powered by a six-cylinder gas engine of 230 cu in. displacement, the tractor provides smooth starts under load through the fluid coupling drive. Four-wheel brakes, automatic coupler, and two recessed, sealed-beam headlights are standard equipment. Heavy-duty, helical-gear, synchromesh transmission provides four speeds forward and one reverse. Final reduction is accomplished directly at each drive wheel through planetary gearing. Maximum forward speed is governed at 16 mph. Two-man seat is foam rubber covered with waterproof, reinforced plastic. Front wheels steer with a leafspring suspension that absorbs shock. Water and fuel filler caps are outside the engine compartment for easy access. All exposed surfaces are painted with weather resistant paint. *Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich.*

Lift Truck: Model QC-20 lift truck with 2000-lb capacity has a four-cylinder, air-cooled engine with high torque characteristics and increased horsepower, constant mesh transmission, repositioned in-

Precision self-alignment

EVEN IN THIS LOW-COST BEARING

BEST SEAL AVAILABLE ANYWHERE! Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Bearing is greased at the factory and shipped in *one piece* . . . no juggling of sundry parts in assembly—simply slip unit on shaft and bolt to support. Its compactness further aids design flexibility.

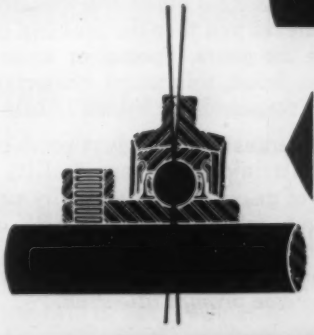


LINK-BELT JPS-200 ball bearings maintain capacity despite shaft and support deflection

IN rugged field service, supporting structures on farm machinery and similar equipment undergo inevitable weaving. Shafts, too, are subject to dynamic deflections. Answer: *self-alignment* — the ability of Link-Belt bearings to adjust under these conditions. And it's yours *at low cost* in this precision Link-Belt ball bearing.

Equally important, Series JPS-200 bearings achieve their economy with *no loss of efficiency*. They combine sturdy pressed-steel housings with standard, full-capacity Link-Belt ball bearings.

Folder 2517 has complete data on the Link-Belt JPS bearing series, and Book 2550 covers the entire Link-Belt bearing line. Get both from any of 40 Link-Belt offices.



FREE ROLLING AND FULL LOAD CAPACITY are maintained even under shaft or support misalignment with Link-Belt self-aligning feature. Extra-long inner ring of bearing assures proper load distribution. Heavy spring-locking collar firmly secures bearing on shaft.

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New Machines

strument panel and improved-design uprights. Optional LP-gas equipment offers increased engine life, longer oil and oil filter life, lower fuel costs, low maintenance cost and reduction of exhaust fumes. An extensive number of job attachments are available for this model. *Hyster Co., Portland, Oreg.*

Metalworking

Milling Machine: Rigidmil universal bed-type milling machine combines longitudinal feed of the table, cross feed of the column and vertical feed of the head. These feed motions are provided by motors independent of the spindle motor, thus providing full horsepower to the spindle. The machine has an all-angle ram-type head, adjustable through an arc of 360 deg both parallel and crosswise to the machine table. Head can be retracted to clear the horizontal spindle when not in use. Twenty-four speed changes are available on both the horizontal spindle and all-angle head in a range from 14 to 1450 rpm. Changes are made from a selector switch on the control pendant. With the main spindle the horsepower range is 1 hp per rpm up to 50 hp maximum; with the all-angle head, the horsepower range is ½ hp per rpm up to 20 hp. Cutter is positioned to work for convenience of loading large workpieces and easier observation of cutting operations. Bed-type design makes possible use of a wider table and longer table feed strokes. Machine is equipped with vernier scales for table, column and head positioning. It has mechanical screw feeds for application of controlled tracing and programming. *Sundstrand Machine Tool Co., Rockford, Ill.*

Lathes: Mondiale line of toolroom and production lathes consists of 12 sizes from 12 x 20 in. to 20 x 100 in. The units have a wide range of speeds and feeds. The 20 x 60 in. geared head lathe has 18 spindle speeds and 56 longitudinal and cross feeds. Speeds, ranging up to 3000 rpm, are selected by a gear box control lever. To insure high surface finish, the final high-speed spindle drive is actuated by a direct V-belt trans-

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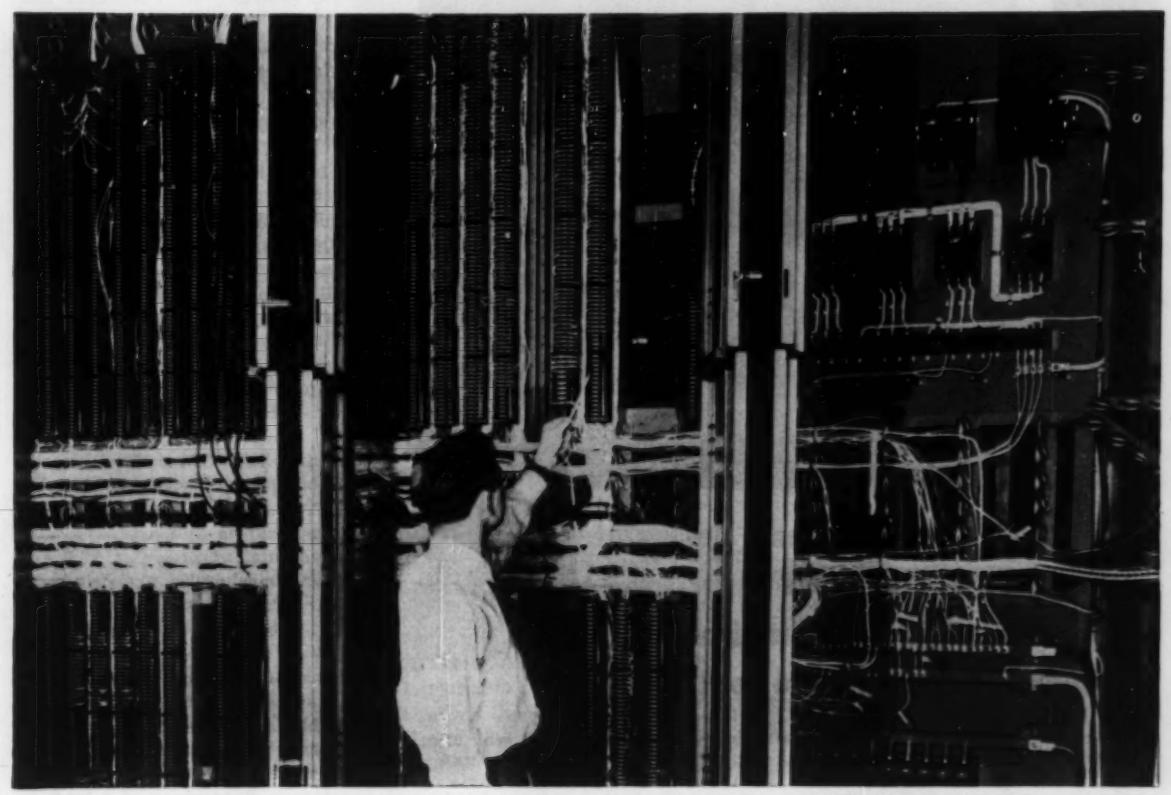

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Circle 531 on page 19

This Quick Demonstration At Your Desk Will Prove How To Get Better, Economical Fastening With Townsend Lockbolts

A few minutes of your time invested in watching a simple demonstration of a better fastening method may point the way to savings of thousands of dollars in assembly of your products. The Townsend lockbolt provides a quick method of producing tight, rigid fastenings that cannot loosen even under extreme vibration or shock conditions.

We would like to have a Townsend engineer demonstrate to you and others in your organization how these lockbolts combine the advantages of riveting and bolting—eliminate the disadvantages. He will show you that installation is fast—that fewer workers can complete an assembly in less time—you improve your product—achieve a lower installed cost.

You will be able to see why the clamping action, or clinch, of Townsend lockbolts is higher than rivets—is more uniform than bolts and nuts. The demonstration will explain how the lockbolt fills the hole better than other fasteners—makes possible a more rigid joint and provides an effective liquid seal.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16" and 3/8" diameters, in grip length ranging up to 2", in various head styles.

For a demonstration on how to speed production, get tight, secure, permanent fastening with Townsend lockbolts write on your company letterhead to Townsend Company, P.O. Box 237-E, New Brighton, Pa.

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New Machines

mission through the gear box to the spindle. Double-wall apron is compact, light and sensitive. Four-way compound toolslide offers speedy changeover. Feedshaft has a tripping device which interrupts longitudinal and cross motions within microscopic limits and protects the lathe against possible overloading. Machines are available in swings from 12 to 20 in. and in all lengths, with or without gap beds. *S & S Machinery Co., Brooklyn, N. Y.*

Wire Rolling Mill: Miniature wire rolling mill flattens and winds small diameter round wire to dimensions accurate within 0.0005-in. The flattened wire is used for a variety of products including hair springs, resistance elements, electronic tube components and wire cloth. Thickest wire handled by the mill is 1/16-in. in diameter. Unit is equipped with water-cooled rolls 2½ in. wide and 4 in. in diameter, and is synchronized with a traversing type recoiler. Mill and recoiling mechanism are driven by rubber, fabric and steel timing belts. Electrical equipment comprises a 10-hp mill motor and a 2-hp recoiler motor powered by a dc system to provide an infinitely variable speed range. Electronic-type short stroke dancing roll unit synchronizes the motors. The unit requires a floor space of 4 by 6 ft. *Stanat Mfg. Co. Inc., Long Island City, N. Y.*

Surface Grinders: Model 618 surface grinders are available in three types: the 618P with powered table and crossfeed; 618PT with powered table and hand-fed crossfeed; and 618H for full hand-feed operation. Reciprocating table is driven by a cogged timing belt, providing a positive nonslip drive. Redesigned cross feed operates within 1½ in. of the end of stroke in both directions. Cross feed is adjustable from 0.006 to 0.100-in. Table motor and spindle motor have overload protection. Hand and power-feed models include a built-in, 300 v-amp transformer for connection of work lights, accessories and controls. Pushbuttons on power models operate on 110 v. Hand feed model is equipped with pushbutton on-off control. Low-pressure automatic lubrication system on all

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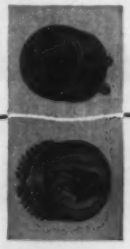

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Circle 533 on page 19

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models maintains constant lubrication protection of all moving parts while grinder is in operation. Work capacity of these models measures 6 x 18 in. Electrical requirements are 220 v, 3 phase, 60 cycle; 440 or 550-v models are also available. *Reid Bros. Co. Inc., Beverly, Mass.*

Packaging

Heat Sealing Machine: Comet 54 UL unit seals unsupported plastic films such as vinyl and polyethylene as well as most coated and laminated barrier materials. It utilizes a heated platen in conjunction with a Teflon-glass fiber clamping pad. The unit is equipped with preset dials for heating and dwell cycles. Two-tube electronic timer controls an electromechanical lock that holds jaws of the pressure platen in position once the foot pedal is depressed. Heating platen can be released at any time. Frame is cadmium-plated steel, finished in grey wrinkle baked enamel. Overall width of the sealing platen is 14 in.; jaw opening is ¾-in. *Product Packaging Engineering, Culver City, Calif.*

Can Packaging System: Jak-Et-Pak unit employs an automatic packaging machine and a carrier carton which wraps around the cans from the top down, glues and locks on the bottom. Carriers package flat-topped, crown-topped and spout-topped cans. Machine handles cans ranging in height from 2⅝ to 7¾ in. and in diameter from 2⅛ to 3¾ in. Carrier blanks are fed from the hopper, which holds 600 blanks. A buzzer warns operator when hopper needs refilling, and the machine stops automatically when hopper is empty. The machine is operated at a speed up to 120 carriers per minute. *Continental Can Co., New York.*

Processing

Polishing Machine: Hydraulic automatic stroke polisher, designated Model 43-R3, polishes either 2B roll mill sheets or formed flat surfaces to an equivalent No. 4 finish or better. It employs a hydraulic system which powers a traveling head at 80 to 90 eight-

R B&W FASTENER BRIEFS

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Technical-ities

By John S. Davey

Tighten bolts to yield strength?

Actually, it is safer to "overtighten" than to undertighten. The following explains why.

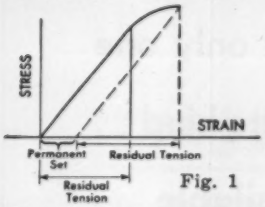


Fig. 1

Up to yield point, the strain in a bolt is proportional to stress. *Beyond* the elastic limit, the bolt goes into its "plastic range". Some permanent stretch takes place. (Fig. 1). Yet while the bolt will not return to original length, note that *residual tension* is fully maintained. And remember, it's *this* force that keeps a bolt tight, determines joint strength.

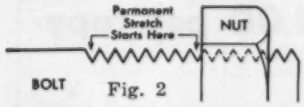
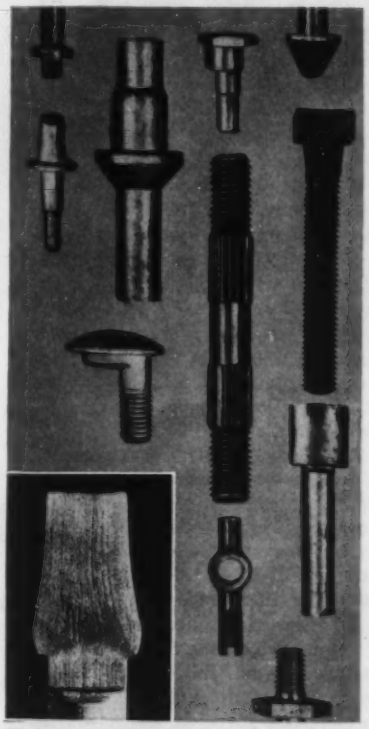


Fig. 2

The permanent set starts at section with highest unit stress —which is at the unengaged threads (Fig. 2). Ultimately, this throws thread pitch off and nut locks, subjecting bolt to torsion (rather than further tightening). This force disappears with wrench-removal. Thus, a bolt can even be torqued well into its plastic range if it won't be reused or need adjustment.

Cold facts on cold headed fasteners



RB&W cold heading machines have forced metal to flow into this typical variety of shaped pieces—just a handful of thousands of different cold headed shapes produced by RB&W to specification. The upset can be at any point, and the shape need not be symmetrical. The continuous, symmetrical flow lines (inset) make metal stronger.

NO ATTEMPT to simplify, improve or economize on fastening is complete without a good look at your screw machine parts, forgings, and certain assemblies that can be reduced to one piece.

You would be surprised at what an expert can produce on cold headers with complete uniformity. Cold heading produces in one piece parts that would otherwise be two or more.

BETTER FLOW LINES

Just as it does with standard fasteners, cold heading makes possible a higher quality, stronger product at high speed and low cost. Properly done, the operation upsets metal along its own axis in continuous flow lines without folds. Stress patterns are better. Fasteners and parts gain greater shear, impact and fatigue strength.

Long a specialist in cold headed fasteners, RB&W offers its experience to designers and production men who want to know whether cold heading is feasible for specific mechanical shapes. If it proves to be so, RB&W facilities can handle your volume needs. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Spin-Lock® Screws solve assembly problem

The designer specified countersunk-head screws to be used in a particular casting. The production man had to stake these in to anchor them. But this meant extra operation, made screw removal damaging and difficult.

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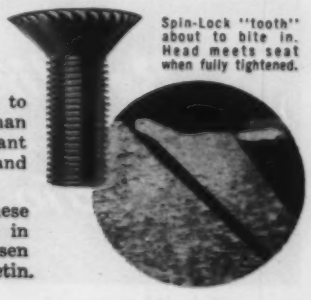

Spin-Lock "tooth" about to bite in. Head meets seat when fully tightened.

Circle 534 on page 19

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Circle 535 on page 19

New Machines

foot strokes per minute. Buff roll mounted on the traveling head backs up the 6-in. wide abrasive belt. Stock table reciprocates under the belt with grind pressure, either by manual or air pressure control. The model can be built to accommodate any length or width capacity. It can also be used for weld removal, surface cleaning prior to painting, scale removal, filler sanding and for other operations. *Carborundum Co., Curtis Machine Div., Jamestown, N. Y.*

Plastic Scrap Granulator: Model G-200 granulator grinds all thermoplastics including vinyl and polyethylene without fluffing. Hot and cold sprues can be fed together. Capacity is up to 250 lb per hr, depending upon material and size of scrap. Hopper chute is hinged and the entire hopper can be removed quickly. Hopper design prevents fly-back. The unit is of welded, all steel construction. One-piece alloy steel rotor is ball-bearing mounted and directly coupled to heavy-duty motor. Standard motor is 1½ hp, 1200 rpm, 220/440 v, 3 phase, 60 cycle, ac. *Van Dorn Iron Works Co., Cleveland.*

Welder: PMM.OC-50-36 unit is is designed to seam and spot weld light gage metals to military and aircraft specifications. Low inertia pressure system exerts a maximum of 120 lb electrode force under air line pressure of 80 psi. It is designed for accurate control of the low electrode force required, and for rapid follow-up. Back-pressure system permits attaining an electrode force as low as 38 lb. Hand-release valve is provided for lowering the upper electrode without pressure for cleaning and alignment. Welding stroke equals ¼-in. plus 3½ in. retraction stroke. Welding transformer is designed for single-phase, ½-cycle unidirectional operation. It is water cooled with a thermostatically controlled solenoid water valve to prevent condensation. Main transformer is rated at 50 kva. Timers include squeeze, heat and cool, hold and off. The machine has a repeat provision for spot welding. *Sciaky Bros. Inc., Chicago.*

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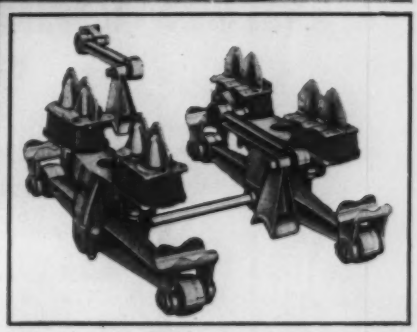

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Circle 536 on page 19

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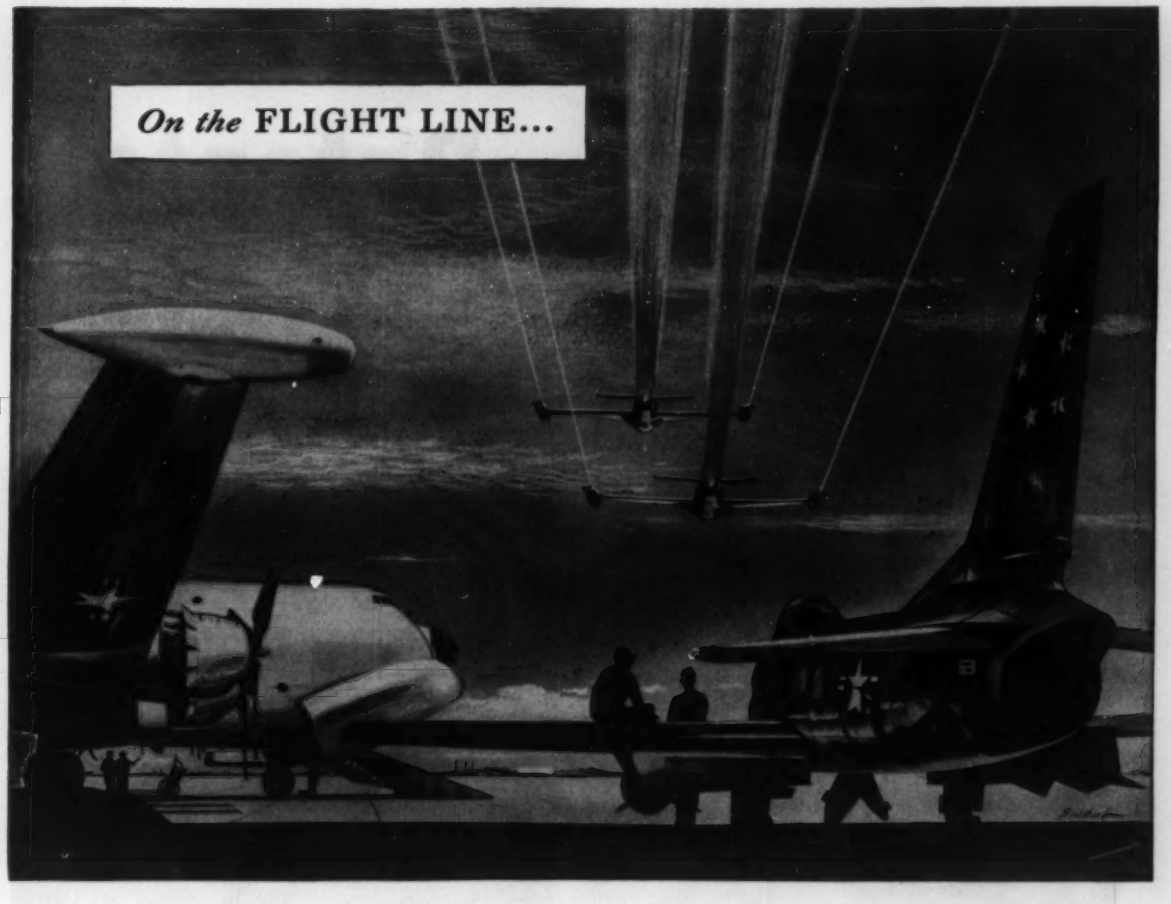

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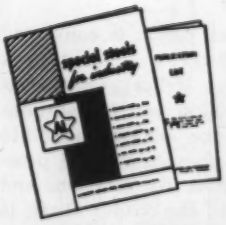
if it's the LAST COST



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Circle 537 on page 19

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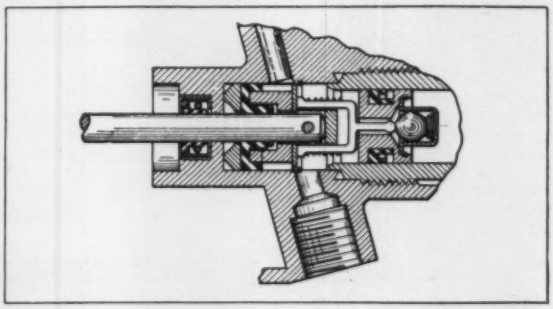
NOTEWORTHY

Patents

Piston-Rod Seal

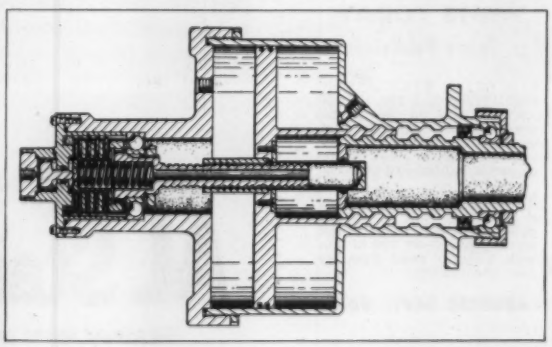
Fluid leakage caused by slip-grab return-stroke action of a reciprocating piston rod is substantially reduced by the interaction of movable and stationary sealing rings in a piston-rod seal assembly. On return stroke of the piston rod (movement to the left),



movable O-ring seal, which is mounted on the piston rod, engages the sealing lip of the U-shaped stationary seal member, ensuring its positive engagement with the rod surface. O-ring moves slightly away from the stationary sealing lip during the piston power stroke (movement to right) to permit some lubrication of the lip and to reduce friction. Application shown here is for a vacuum-boost hydraulic power-brake assembly. *Patent* 2,726,884 *assigned to Bendix Aviation Corp. by Earl R. Price.*

Self-Locking Rotary Actuator

Translation of a fluid-operated piston is converted to rotational motion by a ball-screw element in a self-locking hydraulic actuator. Helical-spline connection between the movable piston and the stationary actuator cylinder causes the piston to rotate slightly during translation. In absence of fluid pressure on either side of the piston, its rotation, and therefore rotational movement of the output shaft, is



Schrader Air Products fill candy molds with chocolate measured to ± 1 gram

Problem: To mass-produce candy figurines, filled solid with chocolate—a tricky sweet to handle. **Solution:** One Buffalo company uses a battery of Schrader Air Cylinders which measure the chocolate to within one gram, and precisely, neatly, swiftly fill the figures.

The uses of Schrader Air Products are limited only by producers' imaginations. Versatile, safe, simple and fast, the hundreds of different units in Schrader's complete line can be employed singly or in combinations to perform automatic operations. And wherever air is used, economies are gained that increase its efficiency even more.

Think air whenever you think automation—in holding or positioning work, moving scraps or chips, or synchronizing actions. Upon request, Schrader engineers will assist you in planning for your best use of air, and in selecting the products best suited to your applications. Outline your problem and we'll be glad to help. Or send for the latest informative booklets which show Schrader Air Products that will simplify your production.

Schrader®
ESTABLISHED IN 1844

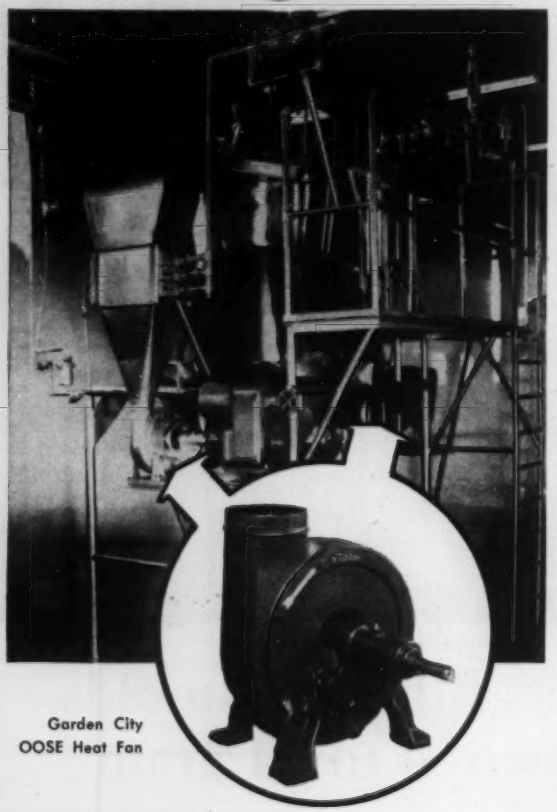
A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

FIRST NAME IN THE USE OF AIR
FOR INDUSTRIAL PRODUCTION AND CONTROL

BLAW-KNOX* chooses

GARDEN CITY FANS

to change liquid milk into dry milk in their remarkable Instantizer!



Garden City OOSE Heat Fan

Fascinating—the way this fabulous Instantizer machine converts milk into powder form! First, the water is extracted . . . then the condensed milk-liquid is exposed to a current of hot, fast moving air (created by a Garden City OOSE heat fan) which effects immediate evaporation. Then another Garden City OOSE fan whisks away the milk powder in a conveyor.

You'll find Garden City fans in other blue-chip industries all over the nation. The advanced engineering features, remarkable efficiency level reported, and the low maintenance cost are among the many reasons why engineers are sold on Garden City.

Dairy Equipment Division, Mora, Minnesota

Write today for free booklet giving complete information.

GARDEN CITY FAN COMPANY
ESTABLISHED 1879

332 S. Michigan Ave.
Chicago 4, Illinois
Dept. G

Representatives in Principal Cities

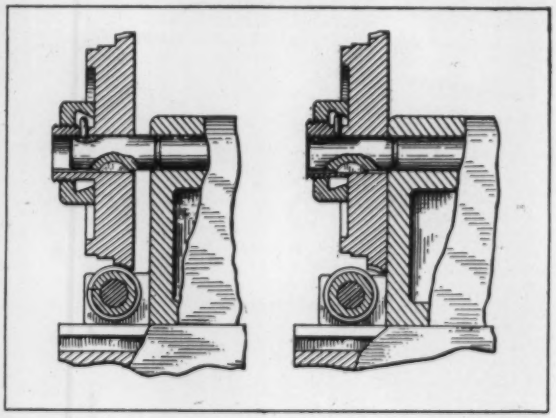
• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

Noteworthy Patents

restrained by a multiple-disk brake (left). Upon application of pressure in either chamber, the brake unit is released, permitting rotation of the screw shaft. Actuator can be locked at any position of the piston, and is automatically locked against rotation in the event of fluid pressure failure. *Patent* 2,773,485 *assigned to General Motors Corp. by Howard M. Geyer.*

Disconnectable Worm Gearing

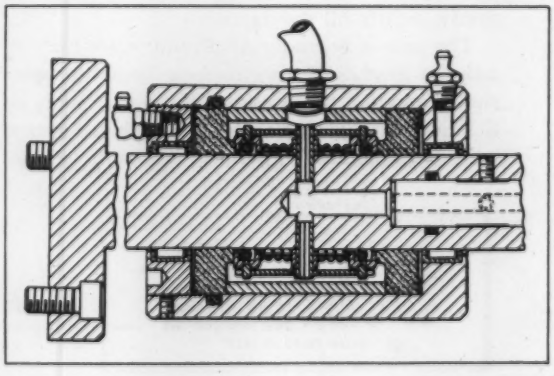
Axial translation of a worm wheel on its shaft permits free rotation of the gear shaft in a disconnectable worm-gear mechanism. In engaged position



of worm and gear (left), gear is fixed on its shaft by a jam nut and detent pin. Rotation of jam nut allows pin to ride free of the gear-shaft detent slot, permitting free translation of the worm gear for disengagement (right). Typical uses include workpiece indexing and repositioning in machine-tool applications. *Patent* 2,769,349 *assigned to South Bend Lathe Works by Otto A. Costello.*

Side-Delivery Rotary Joint

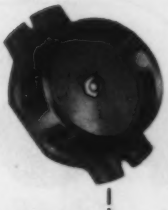
For use where space limitations prohibit installation of an axial-type rotary joint, a side or radial-delivery rotary fitting permits transfer of fluid to a rotating assembly from a stationary source. Spaced graphite seal rings, combined with resilient O-rings, effectively block fluid leakage between stationary and rotating members of the joint at high operating

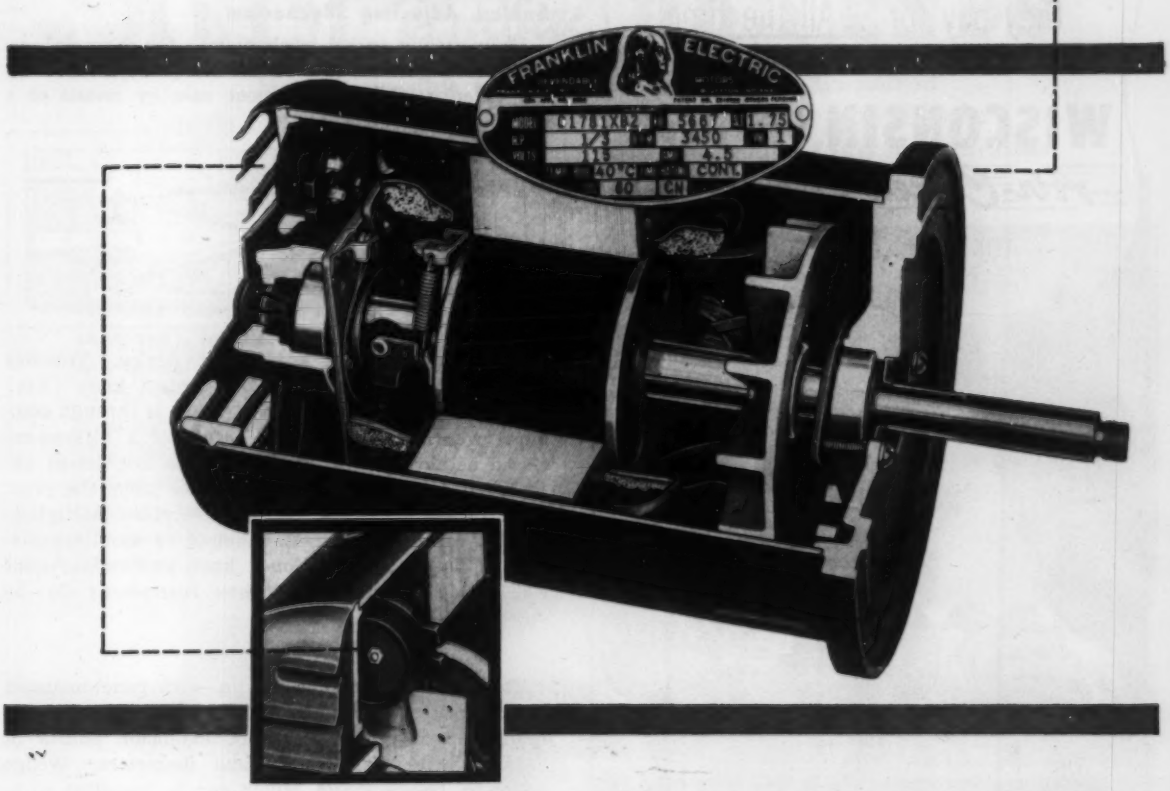


Franklin Motors Count on Built-in

KLIXON PROTECTORS

for positive protection





Leading motor manufacturers have long since recognized the value of built-in Klixon Protectors. They've told us of their satisfaction in many ways . . .

Here's how the Franklin Electric Company of Bluffton, Indiana, puts it:

"No electric motor has any instinct for self-preservation . . . unprotected it will operate under overload until it destroys itself. To prevent this happening in Franklin Motors, we specify and use Klixon Protectors."

They go on to add, "Dependable motor operation requires the positive protection afforded by a Klixon Protector that cuts off power when conditions arise that would otherwise result in certain damage and service shut down.

"The motor shown here is only one of many engineered by Franklin for dependable powering of water systems. And, we feel that Klixon Protectors are a key factor in this dependability."

You, too, can get this dependability in the motors that keep your equipment operating . . . just specify and use Klixon Protected Motors . . . the additional cost is low, pays for itself over and over.

Now There's Something New. In addition to the famous Klixon Protector for single-phase motors, you can now get full protection engineered into 3-phase motors with a single, built-in Klixon Protector. For details, write for Bulletin MOPR1.

KLIXON®

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3202 FOREST STREET, ATTLEBORO, MASS.

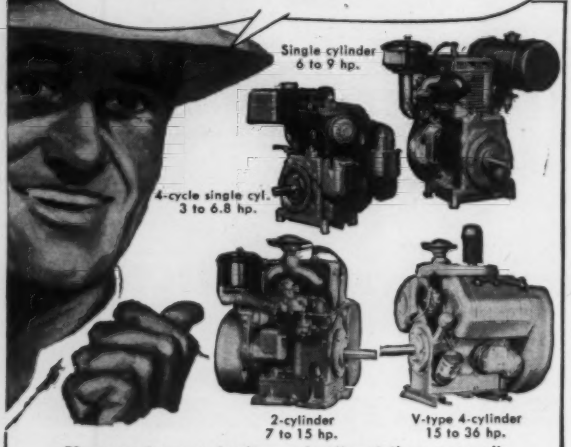
Your customers get all the

POWER

they pay for... All the time when you Specify

WISCONSIN *Heavy-Duty Air-Cooled* ENGINES

for Your Equipment



Your customers don't pay for "part-time power" when your equipment is "Wisconsin-powered". These heavy-duty, industrial-type, air-cooled engines are built with the ruggedness and basic High Torque design that deliver Load-Lugging horsepower day-after-day, month-after-month. Downtime and repairs are held to an absolute minimum because these engines have the endurance and stamina to operate under difficult conditions with only routine maintenance and attention.

Extra-capacity AIR-COOLING means fewer restrictions on engine location—operating equally well at extreme sub-zero or at temperatures up to 140° F. They start easily in any weather, thanks to the high-tension, impulse-coupled OUTSIDE magneto. Pump-circulated lubrication in all models for long-life, low-maintenance service. And heavy-duty components throughout mean dependable operation — even in rough going.

Just as important, there's a Wisconsin Engine to fit both the machine *and* the job. You have your choice of 3 to 36 hp. units in 4-cycle single-, 2-cylinder, and V-type 4-cylinder models. Backed by over 2000 Authorized Service Stations in the U. S. and Canada and in 82 foreign countries.

Standardize on Wisconsin Engines and your customers take the dividends in economical, dependable power. Tell us about your power problem and get a prompt quotation on the unit best suited to your equipment. Write for "Spec" Bulletin S-195.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 6-6002-½

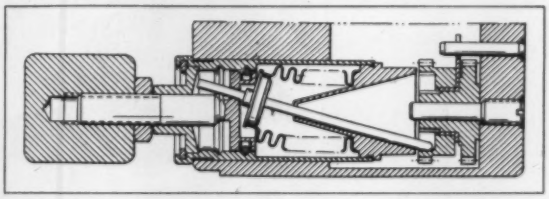
Circle 542 on page 19

Noteworthy Patents

speeds. Configuration of the unit allows it to be positioned between ends of a rotating shaft. *Patent 2,772,897 assigned to Perfecting Service Co. by Harmon L. Shaw and Frank E. Frost.*

Sealed Adjusting Mechanism

Hermetically sealed mechanisms—for example, aircraft instruments—can be manually adjusted from the exterior of the instrument case by means of a



bellows-sealed rotary adjustment device. Transfer of rotational motion from the control knob (left) to the instrument mechanism (right) is through combined rotation and pivoting action of a bellows-enclosed actuating rod. Fine or coarse instrument adjustment is possible with the device since the pivot point of the actuating rod, and therefore multiplication of control motion, is changed by axial translation of the detent-positioned knob and rod. *Patent 2,771,781 assigned to Kollsman Instrument Co. by Josef Von Ranson.*

Control-shaft coupling, for use with panel-mounted potentiometers, switches, and related electrical assemblies, permits selection of extension shafts of various materials, lengths and diameters. Wedge action of the coupling, which can be installed without special tools, grips and rotates the rotor shaft of the controlled component. Unit is particularly applicable where high voltages require spacing of the controlled component away from the mounting panel. *Patent 2,744,777 assigned to Clarostat Mfg. Co. by George J. Mucher.*

Conversion of axial to rotational motion, with either gradual or snap-action rotation, is provided by a permanent-magnet motion-converting device. Repulsion and attraction between a single translating inner magnet and multiple, helically arranged outer magnets provides rotational motion for use in fluid-level controls and similar applications where low-friction operation is essential. *Patent 2,745,027 assigned to Lido Land Co. by Jacob V. Williford.*

Pressure-ratio regulator, which generates an output signal proportional to both error and time integral of error in pressure ratio, gives maximum response to pressure-ratio changes with minimum steady-state instrument error. Typical uses include control of jet engines and other compressible-fluid systems. *Patent 2,767,725 assigned to Marquardt Aircraft Co. by Henry A. Long.*

Simplification and Improvement

HEIM *Unibal* ROD ENDS

Make it possible to reduce the number of component parts formerly used in the link-type parallel and the thread cutter mechanisms on Draper looms. The result of this simplification has been an improvement in the overall operation of the loom.

What is the Heim Unibal?

The outer member can be male (for attaching to a tubular rod), female (for attaching to solid rod stock), or a special shape to fit in with a particular design — but there is only one ball, and it rotates in bronze bearing inserts to correct misalignment in every direction. This Unibal construction provides a large surface supporting area to carry heavier loads. Here is a stock part, made in a wide range of sizes, which can take the place of a specially made assembly and perform better and smoother.

Heim Unibal Bearing used in the lug strap connector in the pick motion.

For the transmission of power at varying angles, consider Heim Unibal Spherical Bearing Rod Ends

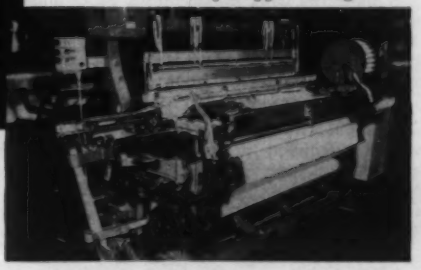
Write for the Heim catalog.

Ask for any engineering aid.

Heim Unibal Rod End

A pair of ¼" Unibal units are used in the thread cutter mechanism.

Four Heim female rod ends are used in the start-stop shipper linkage.



Draper X-2 Model loom

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

Why new PARKER Floats are better than cork or metal

Better than cork! Lighter, can be used in higher temperatures. Parker sealed-cell rubber floats need no protective coating, are resistant to fungus. Won't become waterlogged. Maintain stable weight and volume.

Better than metal! New Parker sealed-cell rubber floats won't fail from vibration or punctures. Can be drilled or machined.

Where can you use them? For all types of aviation and jet fuels, oil, water, and many other liquids. Can be molded in variety of shapes and sizes, with or without metal arm.

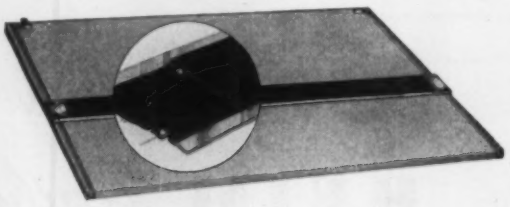
Developed by makers of widely used Parker O-rings.

Write for complete details.
RUBBER PRODUCTS DIVISION
Section 519-N
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio

Parker
Hydraulic and fluid system components

Circle 544 on page 19

MAYLINE



The Mayline Mobile

Finest Straightedge of them all!

A straightedge that moves easily and readily, yet hugs the paper at the slightest pressure. Keeps drawings cleaner. Blade is of phenolic laminate, edges are crystal clear butyrate.

When used with the Mayline counterbalance straightedge will hold position, even at the vertical angle. Other Mayline straightedges are: Regal, Ideal, and E-Z Grip. Available in lengths from 30" thru 96". Ask your dealer for complete information about the Mobile.

MAYLINE COMPANY INC.

601 No. Commerce St. Sheboygan, Wisconsin

MAYLINE

MAYLINE

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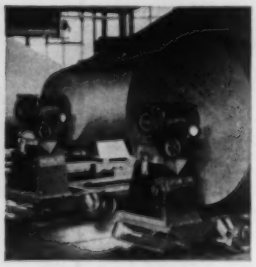
Circle 545 on page 19

USE WAGNER ACTUATING SYSTEMS AND INDUSTRIAL BRAKES...

for Tension Control, Emergency Stops

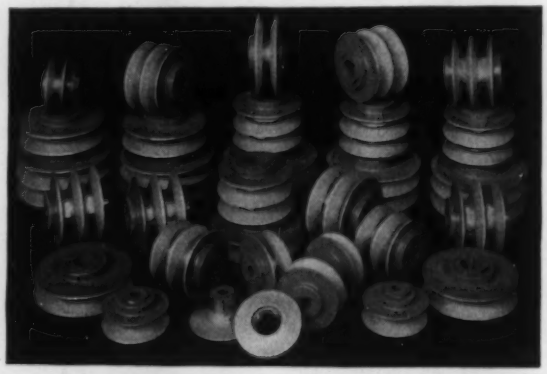


Wagner Industrial Drag Brakes on the paper mill roll stand shown here, keep tension on the roll as paper is fed out to other machinery. Brakes are actuated by a Wagner control cylinder, which is operated by a hand wheel. A Wagner Type H Brake is used in this application.

For *your* specific applications, Wagner can furnish engineered kits with actuators, controls, tubing, fittings —everything required for complete installation. Your nearby Wagner field engineer will get you detailed specifications on a system for your particular application. Call him today.

157-2

Wagner Electric Corporation
6404 PLYMOUTH AVE., ST. LOUIS 14, MO.



BROWNING VARIABLE PITCH SHEAVES

Browning offers the most complete line of FHP sheaves, including 108 variable pitch sizes and types, single and double groove. All are accurately balanced, true running, easily adjusted. With fixed bore or the same *malleable* split taper bushing used in Browning sprockets, couplings, paper pulleys, and other sheaves. Made by experts in power transmission since 1886—Browning Manufacturing Company, Maysville, Kentucky.

Ask your Browning distributor or write us for Catalog V147.

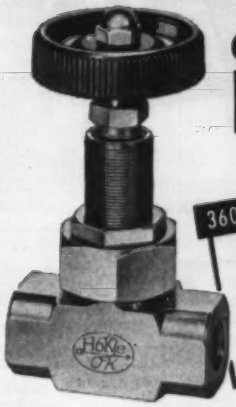
Browning POWER TRANSMISSION EQUIPMENT

Circle 546 on page 19

Circle 547 on page 19

HOKE announces

10 valves in 1



360 SERIES

High Pressure UNION BONNET GLOBE VALVE

For conditions ranging from 3000 psi to low vacuums, or distilled water to corrosive fluids. Series consists of four basic stainless steel bar stock valves... O-ring or Teflon packing with flat Teflon disc or vee point non-rotating, replaceable stem plug... plus six body styles. All parts interchangeable as well as replaceable. Choice of ¼", ⅜" or ½" pipe sizes or Swagelock tube fittings. Panel mounting, too. **Get the facts about this "10 in 1" valve. Write us today.**

HOKE

HOKE INCORPORATED

Fluid Control Specialists

191 S. Dean Street

Englewood, N.J.

Circle 548 on page 19

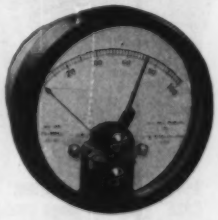
■ NEW METER-RELAYS

FROM 0-5 MICROAMPERES - UP

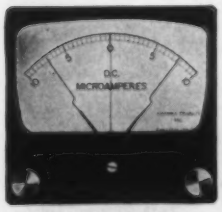
Ruggedized-Sealed, Black Bakelite, or Clear Plastic Cases

D'Arsonval indicating meters with built-in locking contacts for sensitive and accurate control or alarm

TRIP POINT ADJUSTABLE to any point of scale arc. Sensitive to changes as little as 1%. One contact carried on moving pointer. The other on an adjustable pointer. When two pointers meet, contacts close and lock. Holding coil is wound directly over moving coil, locking action is electro-magnetic. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully.



Model 255-C, Single Contact, High Limit, 0-10 Volts DC $42.50



Model 461-C, Double Contact 10-0-10 Microamps DC $83.25

Ranges from 0-5 microamperes or 0-5 millivolts up, full scale. Temperature ranges from 0-300°F. (10 ohms external) have bimetal cold junction compensation. **Standard Contact Rating** 5 to 25 milliamperes DC. Can be built up to 100 milliamperes DC.

Ruggedized-Sealed metal cases are 2½", 3½" and 4½" round, shock-mounted, gasket-sealed.

Black Bakelite case, 4½" rectangular.

Clear Plastic cases are 2½", 3¾", and 4½" rectangular. Maximum visibility and lower cost.

Panel meters and indicating pyrometers are also available in ruggedized-sealed, black bakelite or clear plastic cases. New 40-page catalog lists prices and specifications for meter-relays, meters, pyrometers and automatic controls using meter-relays. Write for Catalog 4-A, **Assembly Products Inc., Chesterland 51, Ohio. HAmilton 3-4436 (Cleveland, O.) West Coast: P.O. Box XX, Palm Springs 51, Calif. Phone DHS 4-3133**

Booth 3916, IRE Show, March 18-21, Coliseum, N. Y. C.

Circle 549 on page 19

Ball-lok pin

the positive locking pin with quick release

REG. U.S. PAT. OFF.

BL-SL HANDLE TYPE

Whenever units are frequently assembled or disassembled the Ball-lok unique principle assures fast, safe and dependable operation. Approved by leading engineers in all phases of electronic, aircraft, commercial and military plants.

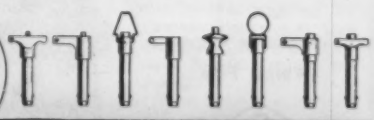
SAFETY • SIMPLICITY • STRENGTH

The one operation pin assures all three . . . just insert pin and *safety* is automatic. The pin cannot be accidentally released without the premeditation of the operator applying thumb pressure to the release button to pull pin. *Simplicity* – the single action pins have less moving parts . . . completely eliminates all need of nuts, bolts, washers, clevis pins or other retaining items. NO TOOLS NEEDED. *Strength* is derived from simplicity of construction combined with the finest materials.

For wider design acceptance, speed of assembly and economy of servicing – specify *Ball-lok pins*. Available in most diameters and lengths to usual bolt standards or manufactured to your specifications.

WRITE FOR FREE ILLUSTRATED BROCHURE 601 ON ALL STANDARD MODELS.

Ball-lok pin



manufactured by D.W. rice corporation

11151 West Pico Blvd. Los Angeles 64

national sales representatives ROWE SALES CO.

Circle 550 on page 19

MOLDED SEAL RING
(ACTUAL SIZE)

LUBRICATION A PROBLEM? . . .

why not try *Purebon

* CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, Purebon is often the ideal solution.

PROPERTIES OF PUREBON

1. Moldable to size.
2. Readily machineable.
3. Chemically inert.
4. Dimensionally stable.
5. Light weight.
6. Low cost where moldable to size.

For complete information about PUREBON write for new Bulletin No. 55, or see Sweet's Product Design File

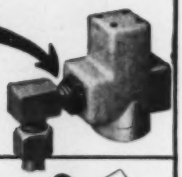
PURE CARBON CO., INC.
442 HALL AVENUE — ST. MARYS, PENNSYLVANIA

Circle 551 on page 19

TRU-O-SEAL STOPS PIPE THREAD LEAKS

TEFLON SEAL

PAT. PENDING



Satisfaction Guaranteed Or Money Back TRIAL OFFER

TRU-O-SEAL fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope. Available in ⅛" to 2½" pipe thread sizes.

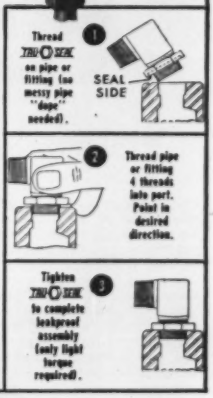
$10.00 Trial Offer No. 1: eight ⅛", ten ¼", eight ⅜", ten ½" pipe thread TRU-O-SEAL Fittings.

$10.00 Trial Offer No. 2: eight ½", ten ¾", four 1" pipe thread TRU-O-SEAL Fittings.

Send order to

TRU-O-SEAL DIVISION
Flick-Reedy Corporation
2006 N. Hawthorne Melrose Park, Ill.

"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Circle 552 on page 19

New advance in... GAUGE SAFETY

Another Marsh development . . . new "SAFE-CASE" gauge for those conditions where over-pressures of explosive force can occur.

Face well protected by solid metal wall; but, still more important, *entire back* is thin metal plate that opens out to exhaust any abnormal pressure.
In testing, heavy blank cartridges, fired within back of case, did not even break crystal.
Use "Safecase" for your toughest services. It is standard in Marsh "Mastergauge"—the highest development in pressure gauges.
Ask for facts.

MARSH INSTRUMENT CO.,
Sales affiliate of Jas. P. Marsh Corp.
Dept. B, Skokie, Ill.
HOUSTON BRANCH PLANT: 1122 Rothwell St. Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada

Test Proves Safety
Explosive force of cartridge merely opens out safety-release back. Back is firmly attached to case and cannot be dislodged during a pressure blow-out.

MARSH GAUGES

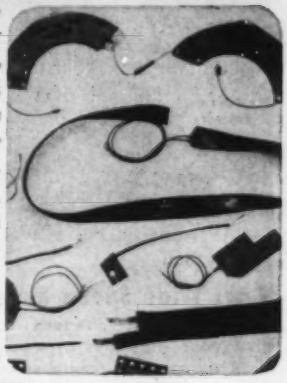
Circle 553 on page 19

SPECIALISTS IN—

HEATING ELEMENTS

ANY SHAPE . . .

also *Any Size*—large, small or very thin—*Light Weight, Tough, Flexible,* as required. Completely *High Voltage Tested.* Operate under *High Pneumatic Pressure. Resist corrosion. Immersable.* Insulated with Silicone Rubber, Neoprene, Kel-F Resin, Polyethylene, etc. Meet *USAF Specs. Low Cost.* Standard units available.



Write or call—

Electro-Flex Heat, INC.

516 ASYLUM ST., HARTFORD 5, CONN. (CHapel 7-2401)

send for free illustrated booklet

FIRST with STANDARD ELEMENTS

Circle 554 on page 19

DRIV-LOK STUDS

Save 60% Fastening Time!

- HOLD PERMANENTLY
- DISASSEMBLED EASILY WITHOUT DAMAGE TO COMPONENTS

Quick, simple insertion . . . Drill Hole and Drive Stud with a single blow.

TYPICAL APPLICATIONS

Attaching name plates or instruction panels

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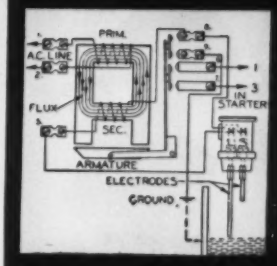
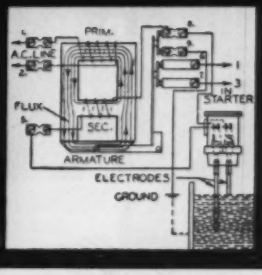
LIQUID LEVEL CONTROL

with the

B/W RELAY





Type LH Relay for Pump Down Control

POSITIVE AND DEPENDABLE

The B/W system of liquid level control consists of a transformer type induction relay and a holder for one or two electrodes, depending on the desired operation and the type of relay used. The relay incorporates a primary or line voltage coil connected to a permanent source of alternating current, and a secondary or electrode circuit coil connected to the electrodes immersed in the liquid being controlled. Energizing the primary coil causes an induced voltage in the secondary coil; thus the secondary coil is never connected to the power line.

LIQUID IS ELECTRICAL CONDUCTOR

The liquid itself is the electrical conductor that completes the secondary circuit. When this secondary circuit is completed, by the liquid contacting both electrodes, the magnetic attraction set up in the legs of the relay core causes the armature to close, and open or close the load contacts. A built-in holding circuit maintains this contact until a predetermined fall in liquid level breaks the circuit. By adjusting the electrode settings, the range of operation can be controlled.

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B/W relays are designed for either pump up or pump down operation. In addition, by using a single electrode they are well suited for signal and alarm applications.

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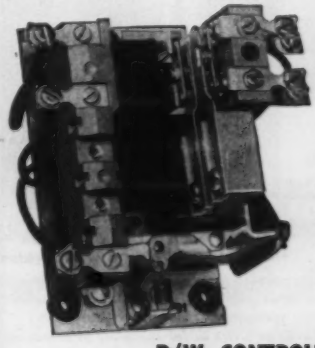

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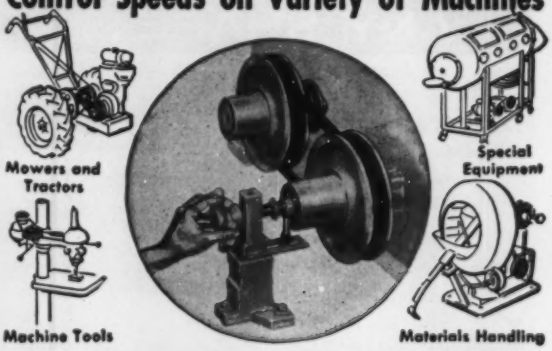

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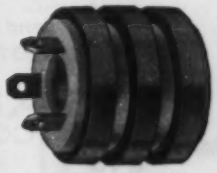

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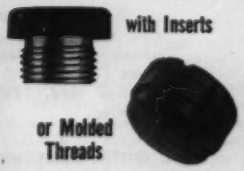

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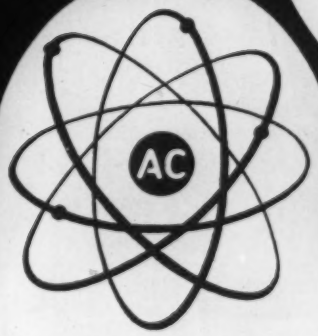

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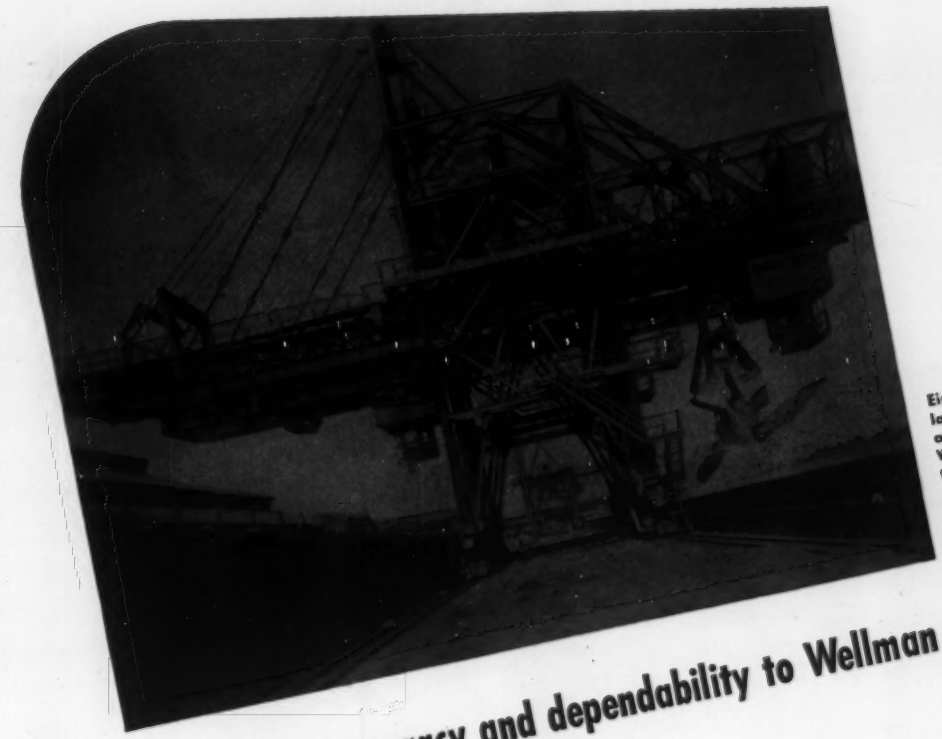
Position.....

Home Address.....



Eighteen compact Cleveland Speed Reducers enable operators of these Wellman ore unloaders to quickly and accurately position the grab buckets over the proper hatch of the freighter alongside the dock.

18 CLEVELANDS give accuracy and dependability to Wellman ore unloaders

FOR 37 years, smooth dependable power transmission for many types of Wellman heavy-duty equipment has been supplied by Cleveland Worm Gear Drives.

On this pair of massive 10-ton iron ore unloaders, 18 Cleveland drives provide a steady, uninterrupted flow of power to the trolleys and driving trucks. So rugged are the trouble-free Clevelands that danger of sudden failure is remote—even if briefly overloaded two to three times their rated capacity.

These Wellman "Work Horses" must be on the job around the clock to quickly unload ore carriers so they can return to the Iron Ranges for another load during the all-too-short Great Lakes shipping season.

Why not let us present the complete story on how Clevelands can dependably and economically handle your power transmission problems? Write today for Catalog 400—it's free. The Cleveland Worm and Gear Company, 3287 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

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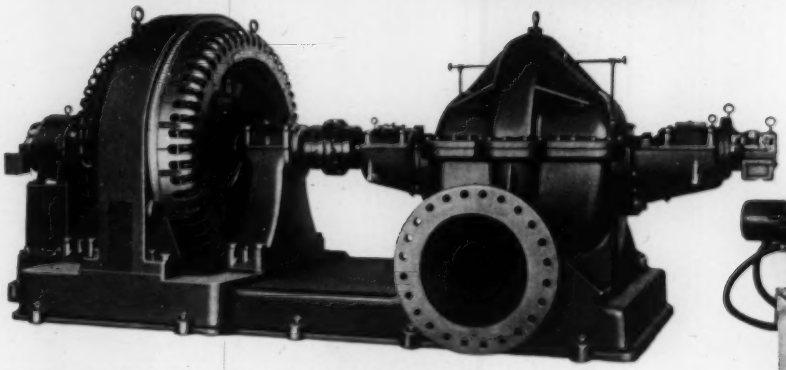
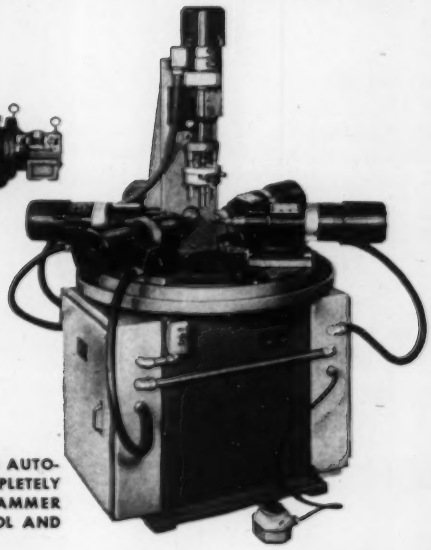
Choice of the Leaders

CUTLER-HAMMER
MOTOR CONTROL
C-H

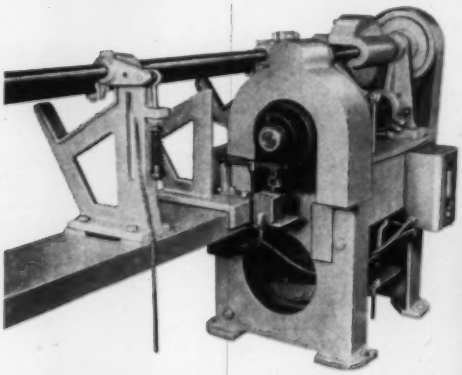
The Mark of Better Machines



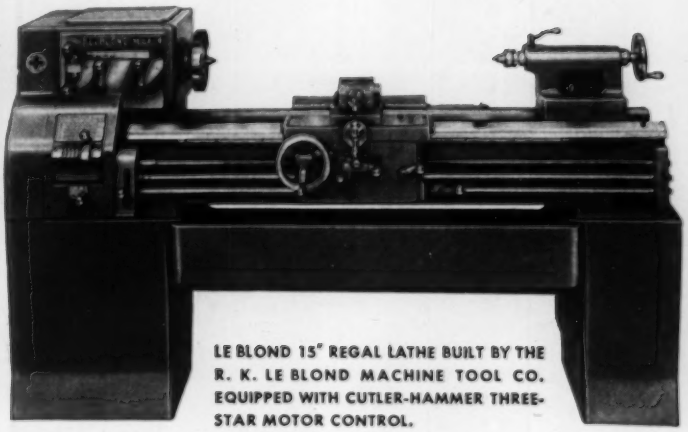
24" MOTOR DRIVEN DOUBLE SUCTION, SINGLE STAGE CENTRIFUGAL PUMP MANUFACTURED BY FAIRBANKS, MORSE & CO. MOTOR CONTROL SUPPLIED BY CUTLER-HAMMER.



GOVRO-NELSON COMPANY'S AUTOMATIC DRILLING UNIT. COMPLETELY EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND ACCESSORIES.



THE SHUSTER AUTOMATIC WIRE STRAIGHTENING AND CUT-OFF MACHINE, MANUFACTURED BY THE METTLER MACHINE TOOL CO. CUTLER-HAMMER THREE-STAR MOTOR CONTROL IS SUPPLIED AS STANDARD ORIGINAL EQUIPMENT.



LE BLOND 15" REGAL LATHE BUILT BY THE R. K. LE BLOND MACHINE TOOL CO. EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL.

Signet of Progress

Winning recognition as a leader in any industry is not easy. But holding that position of leadership year after year is much more difficult. The goal of all competition is to overtake and excel the leader. Recognized leaders among machinery builders *know* they cannot stand still; their machines must forever offer new advanced features, the most advanced construction, the finest in components.

It is very significant that more and more leading machinery builders have standardized on Cutler-Hammer Three-Star Motor Control and Cutler-Hammer Heavy Duty Oil-Tight Pushbuttons and control accessories. Such selections have naturally resulted from careful comparison and proven superiority. When you buy new machines, check the control equipment offered and you will see that Cutler-Hammer Motor Control is clearly the choice of the leaders, definitely the mark of better machines. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

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